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Cave-adapted Plusiocampinae (Diplura, Campodeidae) from the eastern part of the Balkan Peninsula

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Abstract

The fauna of the subfamily Plusiocampinae (Campodeidae) in the caves of the eastern Balkan Peninsula was studied based on specimens collected over the past 40 years by scientists from the National Museum of Natural History at the Bulgarian Academy of Sciences. Two new species are described from Bulgarian caves: *Plusiocampa* (*Plusiocampa*) *balcanica* **sp. nov.**, from the Central Stara Planina Mountains, and *Plusiocampa* (*Stygiocampa*) *petrovi* **sp. nov.**, from the Western Stara Planina Mountains. *Plusiocampa isterina* Condé, 1993 is recorded from Bulgaria for the first time, and the known ranges of several poorly known species are extended to new geographic areas. With the addition of the new species, the total diversity of subterranean Campodeidae in the eastern Balkan Peninsula has increased from 12 to 14 species. This level of diversity is comparable to that of the Dinarides and the eastern Iberian Peninsula – regions of similar size that are also among the richest in subterranean diplurans across Europe.

Key Words

Bulgaria, *Campodea*, *Dicampa*, *Didymocampa*, distribution, fauna, new species, *Plusiocampa*, *Stygiocampa*, taxonomy

Introduction

Diplurans, particularly the subfamily Plusiocampinae Paclt, 1957 within the family Campodeidae Lubbock, 1873, are undoubtedly one of the invertebrate groups most well represented in cave habitats worldwide (Deharveng and Bedos 2018; Sendra et al. 2020a). Plusiocampinae, like other diplurans, are easily distinguished by the presence of a paired appendage at the end of the abdomen, which gives them the common name "two-pronged bristletails." Diplurans typically have small, soft, depigmented bodies, ranging in size from about 1 mm to 80 mm, and lack eyes (Sendra et al. 2021a). Cave-dwelling Plusiocampinae differ noticeably from their soil-dwelling relatives by having slender bodies and exceptionally long appendages – most notably their legs, antennae, and cerci (Condé 1956; Pagés 1964; Sendra et al. 2017, 2020a, 2023).

At present, there are slightly more than 1,000 extant dipluran species described worldwide, and 109 of them belong to Plusiocampinae. Among them, 86% are cave-adapted, living exclusively in caves or other subterranean environments (Condé 1956; Paclt 1957; Sendra et al. 2020b, 2021a, b, c, d, e, 2022). Intensive sampling efforts in Euro-Mediterranean caves have identified this region as a global hotspot for Plusiocampinae diversity, with a remarkable 84 recorded species. Nevertheless, eastern Asia could be the center of origin for this subfamily, although fewer than 20 species have been discovered there so far (Sendra et al. 2021e, 2022).

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In the eastern part of the Balkan Peninsula, a relatively well-studied region, eleven cave-adapted species of Plusiocampinae have been described to date, along with one species of the subfamily Campodeinae (*Campodea* (*Dicampa*) *neuherzi* Condé, 1995). All plusiocampinids belong to the genus *Plusiocampa* Silvestri, 1912 and three of its subgenera. The more diverse subgenus *Plusiocampa* s. str. is represented by eight species: *Plusiocampa* (*Plusiocampa*) *arbanisiensis* Bareth & Condé, 2001, *P.* (*P.*) *beroni* Bareth & Condé, 2001, *P.* (*P.*) *bulgarica* Silvestri, 1931, *P.* (*P.*) aff. *elongata* Ionescu, 1955, *P.* (*Plusiocampa*) *gueorguievi* Bareth & Condé, 2001, *P.* (*P.*) *isterina* Condé, 1993, *P.* (*P.*) *lindbergi* Condé, 1956, and *P.* (*P.*) *vodniensis* Bareth & Condé, 2001. Subgenus *Stygiocampa* Silvestri, 1934 is represented by two species, *P.* (*S.*) *bureschi* Silvestri, 1931 and *P.* (*S.*) *christiani* Condé & Bareth, 1966, while subgenus *Didymocampa* Paclt, 1957 is known from only one species in the region, namely *P.* (*D.*) *euxina* Condé, 1996 (Silvestri 1931; Bareth and Condé 2001; Sendra et al. 2020b, 2021b).

This paper summarizes the results of a study on a significant collection of cave-dwelling diplurans housed at the National Museum of Natural History in Sofia. The specimens were gathered over the past 40 years by Bulgarian biospeleologists and speleologists from caves across Bulgaria and neighboring countries. The collection comprises several hundred specimens collected from more than 60 caves located in mountain ranges such as the Rhodopes, Stara Planina, Pirin, Vitosha, Slavyanka, Vlahina, and Strandzha, as well as from lower-lying regions including the Predbalkan, the Shumen Plateau, the Danubian Plain, and Thasos Island. Notably, the collection includes two species new to science and one species newly recorded for Bulgaria.

A large portion of the studied material was collected by Boyan Petrov, a zoologist at the National Museum of Natural History in Sofia and one of the most active Bulgarian biospeleologists in the past 30 years. In 2018, he went missing without a trace in China while climbing the eight-thousander Shishapangma. For more than two decades, Boyan systematically collected diplurans from caves across the Balkan Peninsula and maintained a database of the material he gathered. After his disappearance, his collection, along with all his research materials, was entrusted to Pavel Stoev, who has continued to curate and manage it. The collection is currently housed in the Invertebrates Department of the museum.

Materials and methods

Sampling

The material was hand-collected in caves during faunal surveys, with pitfall traps employed on two occasions as an additional method. All specimens were preserved in 70% alcohol or mounted on slides. Collections were made from various caves in the eastern Balkan Peninsula, including some of the highest and most inaccessible caves in Bulgaria (over 2,000 m above sea level in the Pirin Mountains), as well as cave systems exceeding 1,000 m in length.

Morphological study

In the laboratory, specimens were washed with distilled water, mounted on slides using Marc André II solution, and examined under a Leica DMLS phase-contrast optical microscope. Illustrations were made with a drawing tube, and measurements were taken with an ocular micrometer. To determine body length, specimens were mounted *in toto* and measured from the base of the distal macrochaetae on the frontal process to the supra-anal abdominal valve. Fourteen specimens were coated with palladium–gold for SEM photography (Hitachi S-4900) and for sensilla measurements. The morphological descriptions and abbreviations follow Condé (1956). The term 'gouge sensilla' is used for the concavo-convex-shaped sensilla on the antennae, following Bareth and Condé (1981).

Abbreviations

For the position of macrosetae, we adopted the abbreviations of Condé (1956).

Thoracic macrosetae: *la* = lateral-anterior; *lp* = lateral-posterior; *ma* = medial-anterior; *mp* = medial posterior. Urotergal macrosetae: *la* = lateral anterior, *post* = posterior. Macrosetae *a* = anterior, *i* = intermediate and *p* = posterior of the insertion line of frontal head. *x* setae of frontal head. Setae sm = sternal medial, sa = subapical and a = apical on abdominal stylus. First urosternite *a1* = glandular setae a_1, *g1* = glandular setae g_1. Labial palp, sg = gustative glandular setae, s = sensillum, os = ordinary setae.

ex. – exemplar (for specimens without sex classification).

Institutional abbreviations

NMNHS National Museum of Natural History at the Bulgarian Academy of Sciences, Bulgaria
MCNB Museu Ciències Naturals de Barcelona, Spain
MUVHN Museu de la Universitat de Valéncia d'Historia Natural
Coll AS private collection of Alberto Sendra, Museu de Ciències Naturals de Valéncia, Spain

Results

Taxonomy

Class Hexapoda Blainville, 1816
Order Diplura Börner, 1904
Suborder Rhabdura Cook, 1896
Family Campodeidae Lubbock, 1873

Subfamily Plusiocampinae Paclt, 1957
Genus *Plusiocampa* Silvestri, 1912
Subgenus *Plusiocampa* s. str. Silvestri, 1912

Plusiocampa (*Plusiocampa*) *arbanisiensis* Bareth & Condé, 2001

Figs 1, 21

Plusiocampa (*Plusiocampa*) *arbanisiensis* Bareth & Condé, 2001: 23, figs 7a–g, 8a, b. Type locality: Lyaskovskata pestera, village Arbanasi, Bulgaria.

Plusiocampa arbanisiensis: Beron, 2015: 92.

New material examined. Bulgaria • 1 male, Predbalkan: Veliko Tarnovo District, Village Arbanasi, Arbanashkata (Lyaskovskata) Cave, 1 Mar. 2011, leg. B. Petrov • Eastern Stara Planina Mts: 3 females, Kotel District, Zlosten, Cave Lednitsata, 726 m alt., stones, clay, 11 Mar. 2011, leg. B. Petrov, S. Deleva, I. Alexandrova • Shumensko Plateau: 1 ex., Shumen District, Cave Biserna (Zandana), 395 m alt., guano, rotten logs, 29 Jan. 2010, leg. A. Hubancheva, I. Borissov • Strandzha Mts.; 1 ex., Burgas District, Village Stoilovo, Cave Golyama vapa, 255 m alt., under stones, guano-clay, 06 Aug. 2006, leg. B. Petrov, T. Stoyanov.

Diagnosis. (Bareth and Condé 2001; Sendra et al. 2020b): Epicuticle smooth at high magnifications. Antennae with 23–26 antennomeres; five simple olfactory chemoreceptors in cupuliform organ; distal whorl of 8–11 gouge sensilla that are 25 µm long; slightly protruding frontal process with non-tuberculated to slightly tubercular setae. Pronotum with 1+1 *ma*, 3+3 *la*, 2+2 *lp* macrosetae; mesonotum with 1+1 *ma*, 3+3 *la*, 2+2 *lp* macrosetae; metanotum with 1+1 *ma*, 1+1 (2+1) *la*, 2+2 *lp* macrosetae; long, barbed notal macrosetae; abundant barbed notal clothing setae. Two ventral tibial macrosetae; subequal claws (ratio 1.05–1.1) with large but narrow lateral crests, posterior claw with a small backward overhang (Fig. 1a). Urotergites I–II with 1+1 *post* macrosetae; urotergite III with 2+2 *post* macrosetae; urotergites IV–V with 1+1 *la*, 5+5 *post* macrosetae; urotergites VI–VII with 2+2 (2+1) *la*, 5+5 *post* macrosetae; urotergite VIII with 6+6 *post* macrosetae; abdominal segment IX with 8+8 *post* macrosetae; urosternite I with 7+7 (Fig. 1b), urosternites II–VII with 5+5, urosternite VIII with 2+2 macrosetae (Fig. 1c); stylus setae with a few distal barbs (Fig. 1d). Male with glandular g_1 setae, subcylindrical appendages with glandular a_1 setae; female appendages similar to those of male (Fig. 1b).

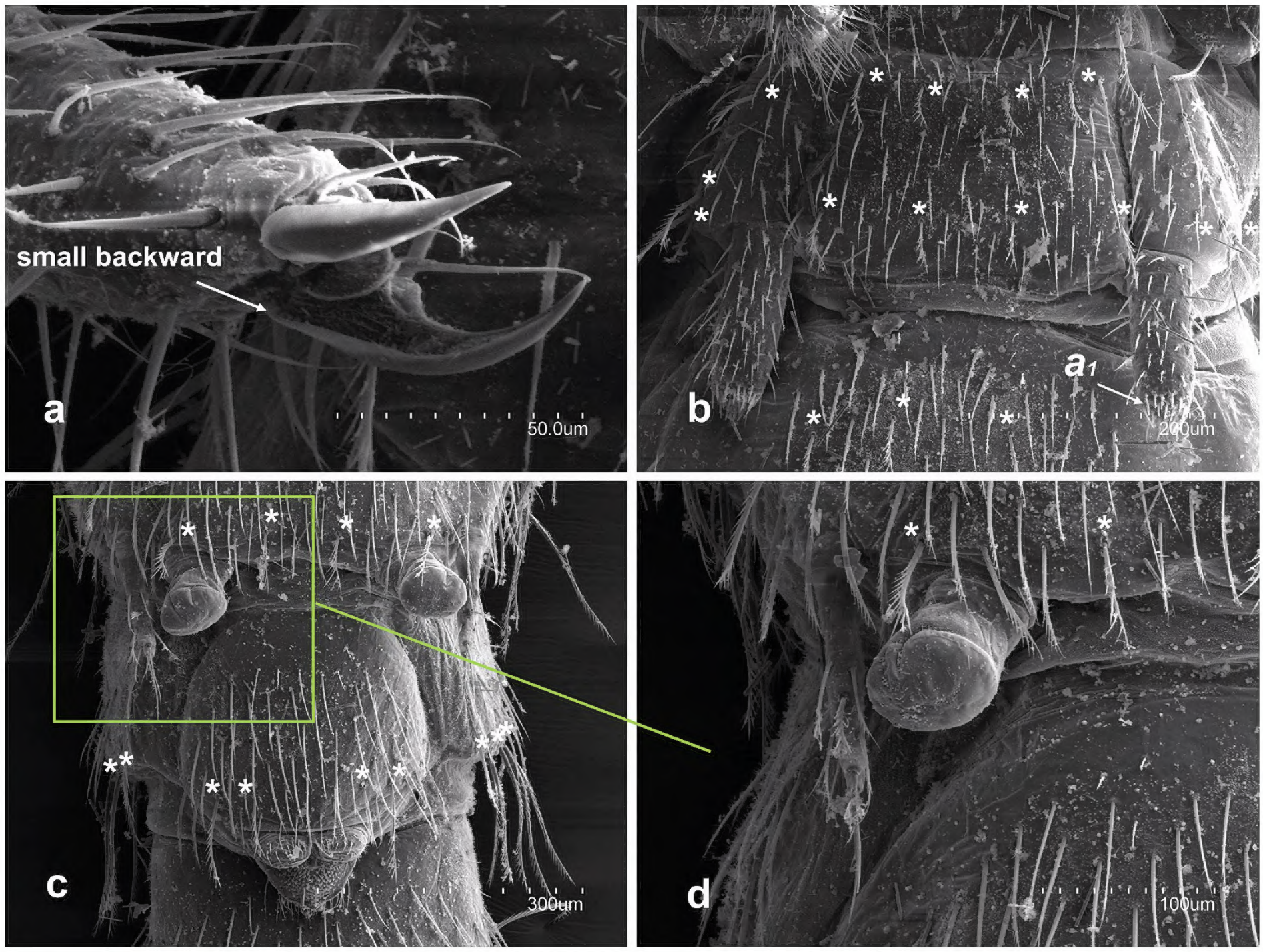

Figure 1. *Plusiocampa* (*Plusiocampa*) *arbanisiensis* Bareth & Condé, 2001, specimens AS coll.; **a.** Pretarsus; **b.** Urosternite I female; **c.** Urosternite VIII of a female; **d.** Detail of exertile vesicle and stylus of the urosternite VII. * Asterisk indicates the presence of a macrosetae. Urosternite I, a_1 glandular setae 1.

Habitat and distribution. Slightly cave-adapted species that has hitherto been found in caves from two geographically distant karst regions in the Balkan Peninsula – the Predbalkan in Bulgaria (Lyaskovskata Cave, the type locality) and the Karst Plateau in Slovenia (two caves near the town of Sežana). Here, we re-establish the species from its type locality (Arbanashkata Cave, also known as Lyaskovskata Cave), as well as from three additional caves in Bulgaria located in distinct geographical regions: the Eastern Stara Planina Mountains, the Shumen Plateau, and the Strandzha Mountains. As a result, the known range of the species is extended by approximately 200 km to the southeast and 100 km to the northeast of the type locality (Fig. 21).

Plusiocampa (*Plusiocampa*) *beroni* Bareth & Condé, 2001

Figs 2–4, 21

Plusiocampa (*Plusiocampa*) *beroni* Bareth & Condé, 2001: 16, figs 3b, 4a–e. Type locality: Cave Magura, village Rabisha, Vidin District, Bulgaria.

Plusiocampa (*Stygiocampa* [sic!]) aff. *beroni*: Beron et al., 2011 610.

Plusiocampa (*Stygiocampa* [sic!]) *beroni*: Beron, 2015: 92.

Plusiocampa (*Stygiocampa* [sic!]) cf. *beroni*: Beron, 2015: 92.

New material examined. Bulgaria: Western Rhodopes Mts. • 13 ex., Gotse Deltsev District, Village Ribnovo, Cave Manuilovata, 1182 m alt., 30 Apr. 1994, leg. B. Petrov • 2 ex., Gotse Deltchev District, Village Gospodintsi, Cave Salievata, 02 Nov. 1994, leg. B. Petrov • 4 ex., Pazardzhik District, Peshtera town, Kupena Reserve, Cave Novata Peshtera, 540 m alt., 17 Oct. 1992, leg. B. Petrov • 3 ex., same locality and collector, 07 Nov. 2004; 6 ex., same locality, 27 Jun. 1986, leg. P. Beron • 4 ex., Kupena Reserve, Cave Vodnata Peshtera, 27 Jun. 1986, 890 m alt., leg. P. Beron • 4 ex., same locality, 02 Jul. 2006, leg. P. Stoev, B. Petrov • 1 ex., Kupena Reserve, Village Ravnogor, Cave Pavla, 1322 m alt., 01 Jul. 2006, leg. B. Petrov and P. Stoev; Vlahina Mountain • 3 ex., Blagoevgrad Distr., Village Logodazh, Cave Boichova Dupka, 14 Sep. 1994, leg. B. Petrov; Predbalkan • 2 males, 3 females, Lovetch District, Village Dragana, Sinyoto Ezero Cave, 25 Aug. 1985, leg. B. Garev.

Diagnosis. (Bareth and Condé 2001): Epicuticle smooth at high magnifications (Fig. 4b). Antennae with 26–29 antennomeres; distal whorl of 24–26 gouge sensilla that are 30 µm long (Fig. 2a–c); 6–8 complex olfactory chemoreceptors on cupuliform organ, each with a prominent central protrusion surrounding a single fold (Fig. 2d); border of cupuliform organ with a whorl of presumably glandular setae long and short, long ones with a shallow distal part with an apical opening (Fig. 2d, e); non-protruding frontal process with non-tubercular setae. Pronotum with 1+1 *ma*, 3+3 *la*, 2+2 *lp* macrosetae; mesonotum with 1+1 *ma*, 3+3 *la*, 2+2 *lp*, 1+1 *mp* macrosetae (Fig. 3a, b; metanotum with 1+1 *ma*, 1+1 (2+1) *la*, 2+2 *lp*, 1+1 *mp* macrosetae; long, barbed notal macrosetae; abundant notal clothing setae. Two ventral tibial macrosetae; unequal claws (ratio 1.10–1.30) with large lateral crests, posterior claw with a backward overhang (Fig. 3c–f). Urotergites I–II with 1+1 *post* macrosetae; urotergites III with 2+2 *post* macrosetae (1+1 *la*, 1+1 *post* on one specimen from Novata Peştera, western Rhodope); urotergite IV with 1+1 *la*, 4+4–5+5 *post* macrosetae; urotergite V with 1+1–2+2 *la*, 5+5 *post* macrosetae; urotergites VI–VII with 2+2–3+3 *la*, 5+5 *post* macrosetae; urotergite VIII with 6+6 *post* macrosetae; abdominal segment IX with 8+8 *post* macrosetae; urosternite I with 7+7, urosternites II–VII with 5+5, urosternite VIII with 2+2 macrosetae (Fig. 4); stylus setae with a few barbs (Fig. 4b). Male with an area of glandular g_1 setae, subcylindrical appendages with glandular a_1 setae (adults from Gruffre Padez, Sofia with short, thick appendages with a large area of glandular a_1 setae); female with subcylindrical appendages with glandular a_1 setae. Spermatozoid fascicle wheels with 2 turns of 50 µm long and 5 µm diameter filament.

Habitat and distribution. This species was originally described from Magura Cave near the village of Rabisha in northwestern Bulgaria (Bareth and Condé 2001). In the same publication, the authors also reported it from another cave in the region – Varkan near the village of Druzhba. Two other records – though uncertain – have been reported from Padezh Cave near the village of Breze and Novata Cave near the town of Peshtera.

Here, we confirm the species' presence in caves in the Peshtera area and report its occurrence in other caves in the Rhodopes along the Mesta Valley, as well as in one cave in the Vlahina Mountain and one in the Predbalkan region. Thus, the species appears to be distributed across parts of western Bulgaria, although its range remains highly fragmented, with confirmed presence in only 10 caves to date (Fig. 21).

Despite being found exclusively in subterranean habitats, the species does not exhibit strong adaptations to the cave environment.

Plusiocampa (*Plusiocampa*) *bulgarica* Silvestri, 1931

Figs 5–9, 21

Plusiocampa (*Plusiocampa*) *bulgarica* Silvestri, 1931: 103, figs vi–viii. Type locality: Cave Charamijskata, village Trigrad, Bulgaria.

Plusiocampa bulgarica: Bareth, 1974: 657.

Plusiocampa (*Stygiocampa* [sic!]) *bulgarica*: Beron et al., 2011: 610.

Plusiocampa (*Stygiocampa* [sic!]) *bulgarica*: Beron, 2015: 92.

New material examined. Bulgaria: Western Rhodopes Mts. • 2 ex., Asenovgrad District, Village Mostovo, Cave Gargina Dupka, 900 m alt., 14 Mar.1992, leg. B. Petrov • 2 ex., same locality, 19 Apr. 1993, leg. P. Stoev • 2 males, same locality, guano, rocks, 26 Feb. 2009, leg. S. Deleva, A. Pavlova • 1 female, same locality, pitfall traps, 10 Apr. 2010–18 Apr. 2011, leg. S. Deleva • 1 ex., Asenovgrad District, Village Belitsa, Shepran Dupka Cave, 850 m alt.,

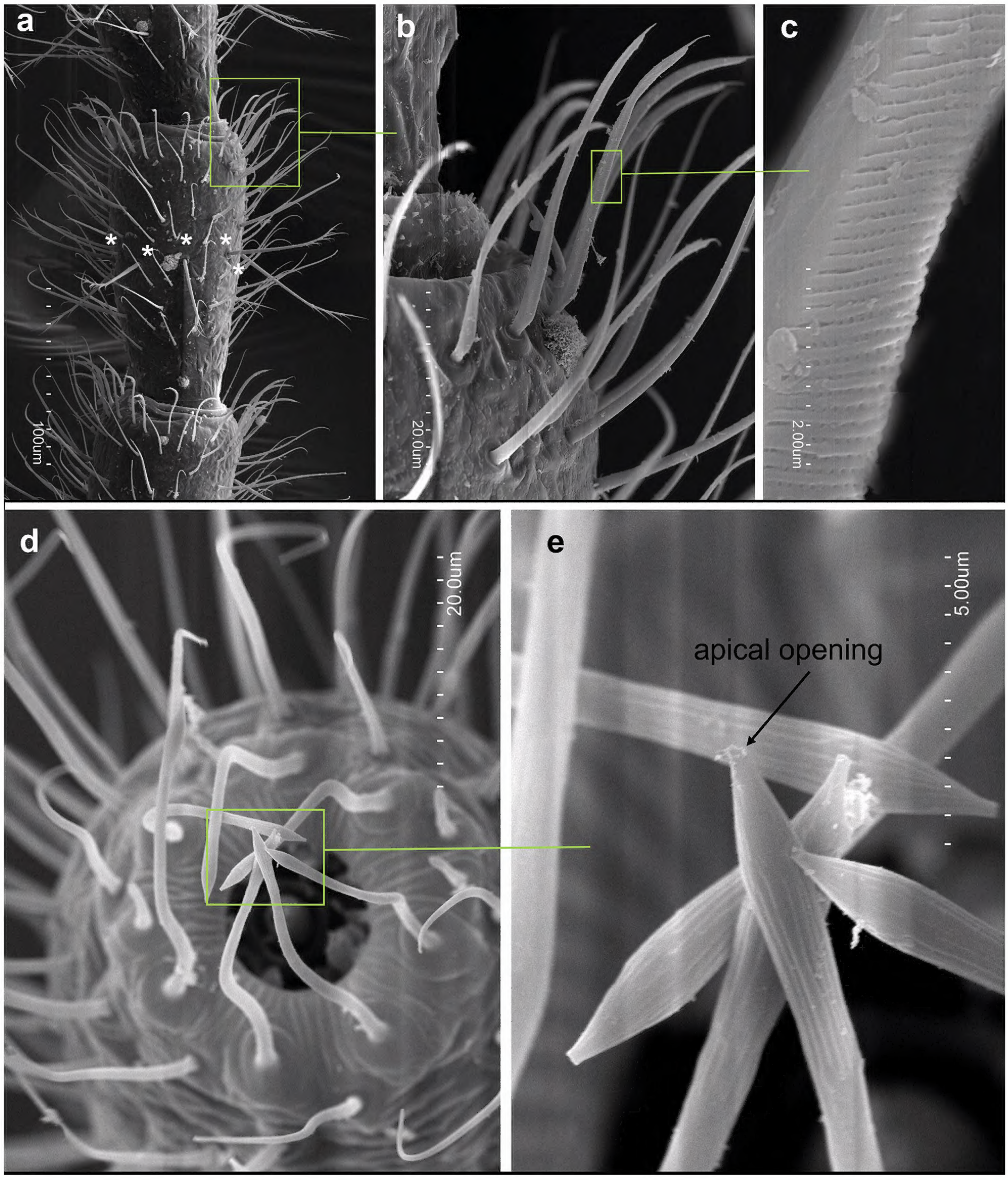

Figure 2. *Plusiocampa* (*Plusiocampa*) *beroni* Bareth & Condé, 2001, specimens AS coll.; **a.** Medial antennomere; **b.** Detail of lateral distal portion of medial antennomere; **c.** Detail of gubia sensillum; **d.** Cupuliform organ apical antennomere; **e.** Detail of presumably glandular setae around cupuliform organ. * Asterisk indicates the presence of a macrosetae.

08 Oct. 2005, leg. B. Petrov, T. Ivanova, I. Borisov • 17 ex., Asenovgrad District, Village Orehovo, Cheloveshkata Peshtera cave, 1110 m alt., 14–15 Nov. 1992, leg. P. Stoev • 3 ex., same locality, 07 Jun. 2007, leg. B. Petrov, P. Stoev • 2 ex., Laki District, Agovski Kamak area, Village Dryanovo, Cave Biserna, 1140 m alt., 09 Oct. 2005, leg. B. Petrov, I. Borisov, T. Ivanova • 1 female, 1 juvenile, Laki District, Village Dryanovo, Lisek Cave, 15 Nov. 2009, leg. S. Deleva • 3 females, 1 male, 1 juv., Laki District, Staro Selo close to Village Dryanovo, Cave Barzibogovata, 1110 m alt., 20 Oct. 2005, leg. I. Borisov • 10 ex., Dospat District, Village Borino, Hut Orphei, Cave Izvora, 20 Mar. 1993, leg. T. Ivanova • 1 ex., Chepelare District, Village Zabardo, Cave Tamnata Dupka, 1250 m

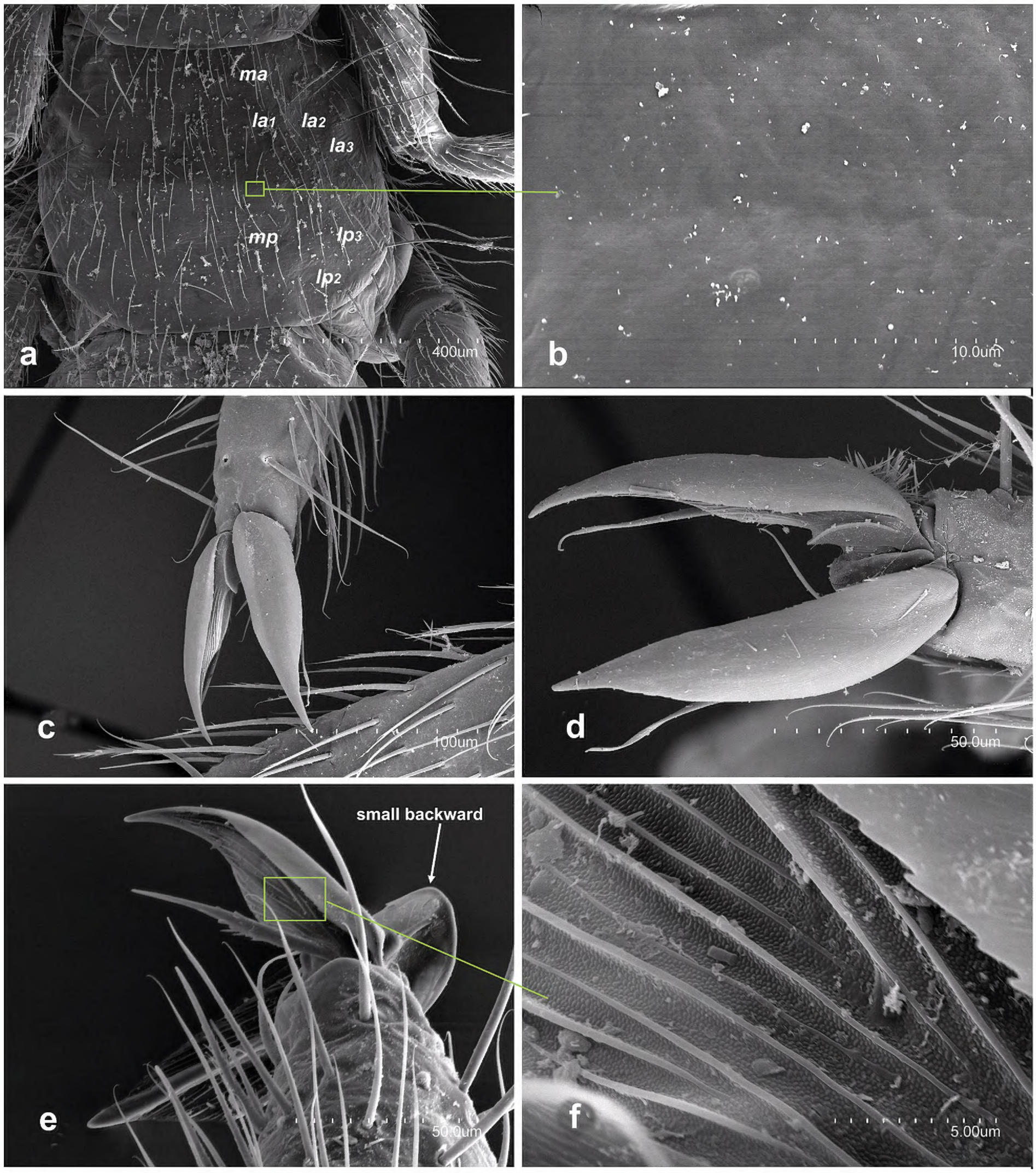

Figure 3. *Plusiocampa* (*Plusiocampa*) *beroni* Bareth & Condé, 2001, specimens AS coll.; **a.** Mesonotum; **b.** Detailed surface of epicuticle at high magnifications; **c.** End of tarsus and pretarsus of metathoracic leg, latero-dorsal side; **d.** End of tarsus and pretarsus of metathoracic leg, dorsal side; **e.** End of tarsus and pretarsus of metathoracic leg, latero-dorsal side, latero-ventral side; **f.** Detail of grooves on ventral side of pretarsus of a metathoracic leg. Thoracic macrosetae (*ma*) medial anterior; (*la1*) lateral anterior 1: (*la2*) lateral anterior 2; (*la3*) lateral anterior 3: (*mp*) medial posterior; (*lp2*) lateral posterior 2; (*lp3*) lateral posterior 3.

alt., clay, 20 Mar. 2004, leg. B. Petrov, T. Stoyanov • 7 ex., same locality, 22 May 2010, leg. B. Petrov, P. Beron, T. Georgieva, S. Stoycheva • 3 ex., town Chepelare, Cave Samurskata, 28 Nov. 1994, leg. B. Petrov • 4 ex., Devin District, Village Trigrad, Cave Suhodolska, 1400 m alt., 13 Jul. 1997, leg. B. Petrov • 4 ex., Devin District, Village Yagodina, Cave Gorna Karanska, 1100 m alt., 04 Aug. 1997, leg. B. Petrov • 66 ex., same locality, trap at the end of the cave, 12 Mar. 1998 leg. B. Petrov • 2 ex., Devin District, Village Yagodina, Sanchova Dupka Cave, 990 m alt., clay-guano, 17 Sep. 2005, leg. B. Petrov • 1 ex., Devin District, Village Kesten, Cave Forgovo 1, 1300 m alt., 01 Oct. 2000, leg. B. Petrov • 2 ex., Devin District, Village Breze, Cave Byaloto Kamene, 1230 m alt., 04 Mar. 2007,

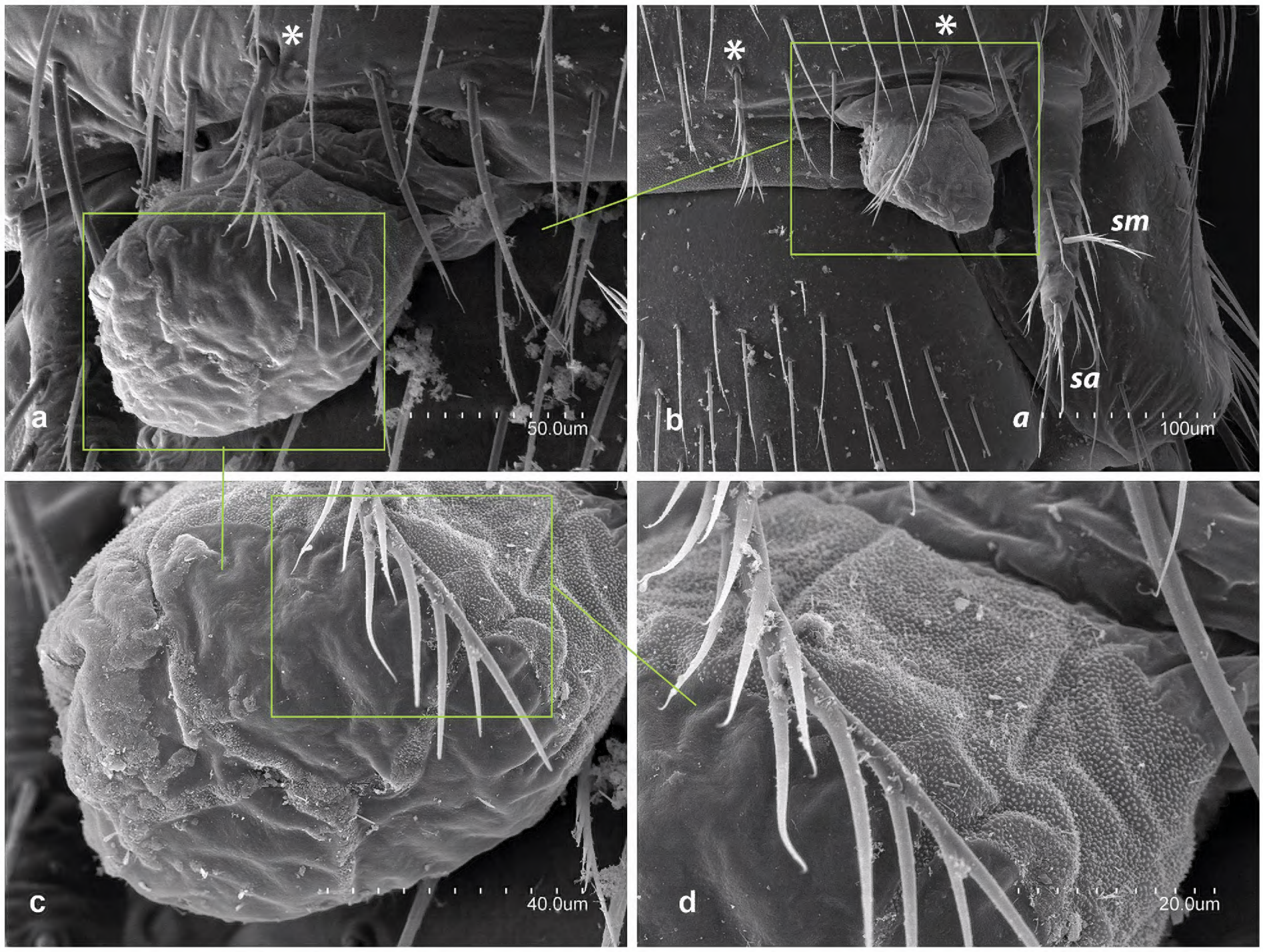

Figure 4. *Plusiocampa* (*Plusiocampa*) *beroni* Bareth & Condé, 2001, specimens AS coll.; **a.** Exertile vesicle of urosternite VII; **b.** Latero-posterior portion of urosternite VII and latero-anterior of urosternite VIII with exertile vesicle and stylus; **c.** Exertile vesicle, urosternite VII; **d.** Detail of exertile vesicle, urosternite VII. * Asterisk indicates the presence of a macrosetae. (*sm*) sterno-medial seta; (*sa*) subapical seta; (*a*) apical seta on stylus.

leg. B. Petrov • 2 ex., Smolyan District, Village Mogilitsa, Cave Uhlovitsa, 1000 m alt., 06 Aug. 1999, leg. B. Petrov, V. Beshkov • 2 ex., Smolyan District, Village Progled, Cave Sbirkovata, 1350 m alt., 07 Aug.1999, leg. B. Petrov, V. Beshkov • 1 male, same locality, 21 May 2017, leg. D. Georgiev • 10 ex., Smolyan District, Village Borikovo, Cave Borikovskata, 1120 m alt., clay, rotten wood, 19 Mar. 2004, leg. B. Petrov • 4 ex., Smolyan District, Village Borikovo, Borikovskata Peshtera Cave, 01 Jun. 2003, leg. T. Ivanova • 2 ex., Smolyan District, Village Gela, Cave Lednitsata, 1620 m alt., 19 Sep. 2005, leg. B. Petrov • 1 ex., Smolyan District, Village Dolno Vlahovo, Cave Potoka, 1150 m alt., 16 Jul. 2006, leg. B. Petrov • 2 ex., Smolyan District, Village Mogilitsa, Cave Byala Voda, 1045 m alt., 13 Jul. 2006, leg. B. Petrov • 1 ex., Smolyan District, Village Polkovnik Serafimovo, cave near Pametnika, 1080 m alt., 14 Jul. 2006, leg. B. Petrov • 4 ex., Smolyan District, Pamporovo, Mecha Dupka Cave, 1560 m alt., under stones in clay, 19 Oct. 2006, leg. B. Petrov, T. Stoyanov • 3 ex., Rudozem District, Village Boevo, Cave Boevskata, 1065 m alt., 14 Jul. 2006, B. Petrov leg.; Eastern Rhodopes Mts. • 1 ex., Dzhebel District, Village Stremtsi, Gyaurhambar Cave, 520 m alt., 08 Jun. 2007, leg. P. Stoev, B. Petrov; Pirin Mts. • 3 ex., Cave Aleko, 1692–1760 m alt., 41.72768°N, 23.32350°E, 26 Jun. 2002, leg. B. Petrov • 1 ex., same locality, 20.11.2011, leg. N. Toshkova • 1 ex., Banski Suhodol, Cave BS25, BFSp No. 2557, 41.79817°N, 23.40306°E, 2310 m alt., 02 Sep. 2013, leg. S. Goranov, S. Deltshev leg. • 5 ex., Sandanski District, above Village Ilindentsi, Cave Sharaliiska Peshtera, 1650 m alt., 21 Aug. 2002, leg. B. Petrov, P. Beron; Predbalkan • 1 ex., Pleven District, Village Dragana, Cave Skoka, under stones, clay-guano, 29 Jan. 1998, leg. B. Petrov, T. Ivanova, T. Troanski.

Diagnosis. (Silvestri 1931; Bareth and Condé 2001; Sendra et al. 2020): Elongated body (Figs 6a, 7a). Epicuticle smooth at high magnifications (Fig. 7c). Antennae with 24–30 antennomeres; distal whorl of 30–36 gouge sensilla that are 45–60 µm long with an apical thin extension (Fig. 5c–f); 10 complex olfactory chemoreceptors in cupuliform organ each with two concentric floods around a central protrusion (Fig. 7a); border of cupuliform organ with a whorl of presumably glandular setae long and short, long ones with a shallow distal part with an apical opening (Fig. 5a, b); protruding frontal process

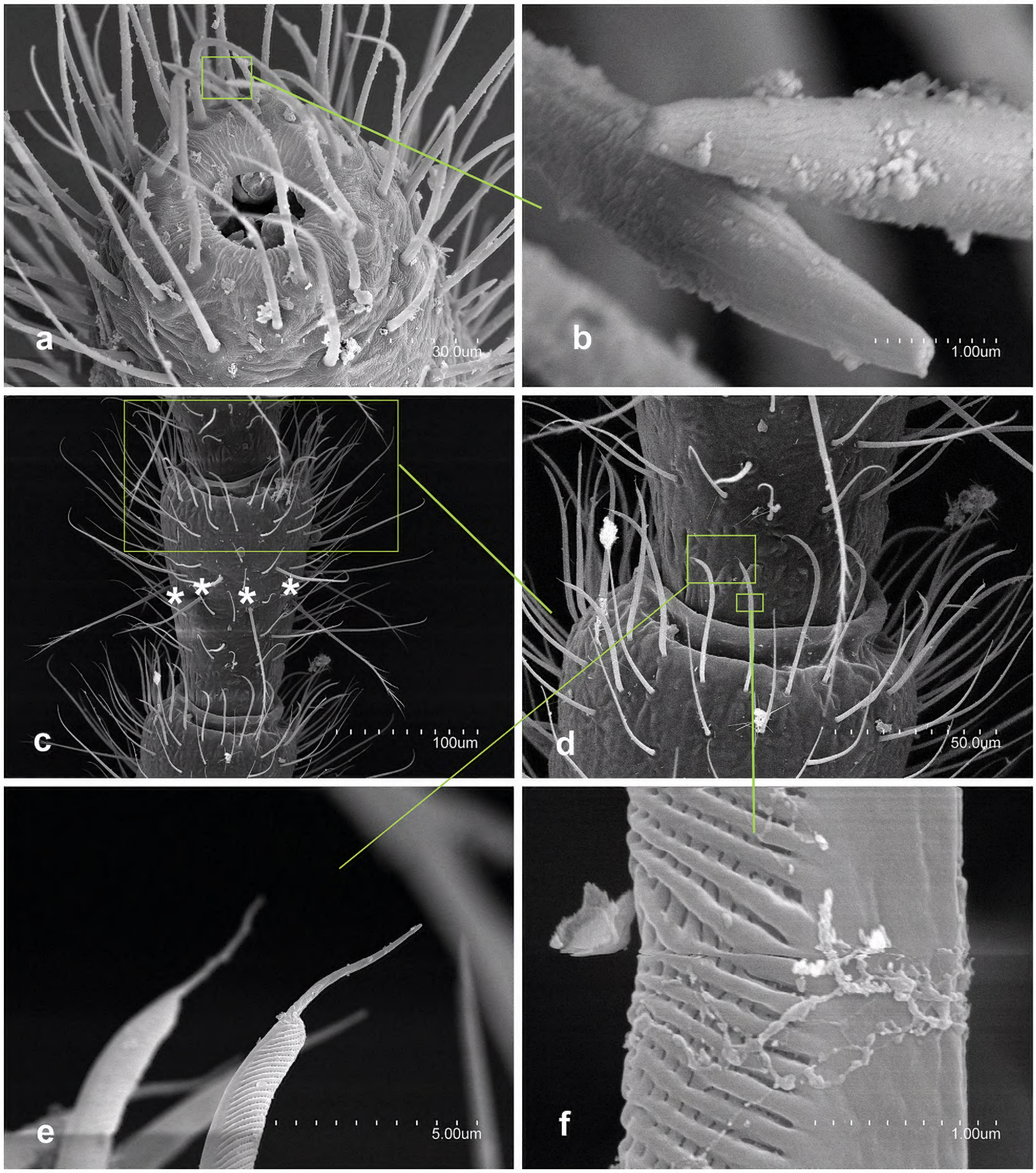

Figure 5. *Plusiocampa* (*Plusiocampa*) *bulgarica* Silvestri, 1931, with tuberculate frontal process, specimens AS coll.; **a.** Cupuliform organ; **b.** Detail of presumably glandular setae around cupuliform organ; **c.** Medial antennomere; **d.** Distal portion of medial antennomere; **e.** Detail of gouge sensilla, apical portion; **f.** Detail of gouge sensillum, medial portion. * Asterisk indicates the presence of a macrosetae.

with tubercular setae in most of the population (Fig. 6b), rarer non-tuberculated population. Pronotum with 1+1 *ma*, 4+4 *la*, 2+2 *lp* macrosetae; mesonotum with 1+1 *ma*, 3+3 *la*, 2+2 *lp*, 1+1 *mp* macrosetae; metanotum with 1+1 *ma*, 2+2 *la*, 2+2 *lp*, 1+1 *mp* macrosetae; long, barbed notal macrosetae; a few long, distally barbed notal clothing setae (Figs 6c, d, 7b). Two or three ventral tibial macrosetae; unequal claws (ratio 1.30–1.5) with large lateral crests, posterior claw with a large backward overhang (Fig. 8a–d). Urotergites I–II with 1+1 *post* macrosetae; urotergite III with 0+0–1+1 *la*, 1+1–2+2 *post* macrosetae; urotergite IV with 1+1 *la*, 5+5 *post* macrosetae; urotergites V with 2+2 *la*, 5+5 *post* macrosetae; urotergites VI–VII with 3+3 *la*, 5+5 *post* macrosetae; urotergites VIII with 6+6 *post* macrosetae; abdominal segment IX with 8+8 *post* macrosetae (Fig. 7d, e). Urosternite I with

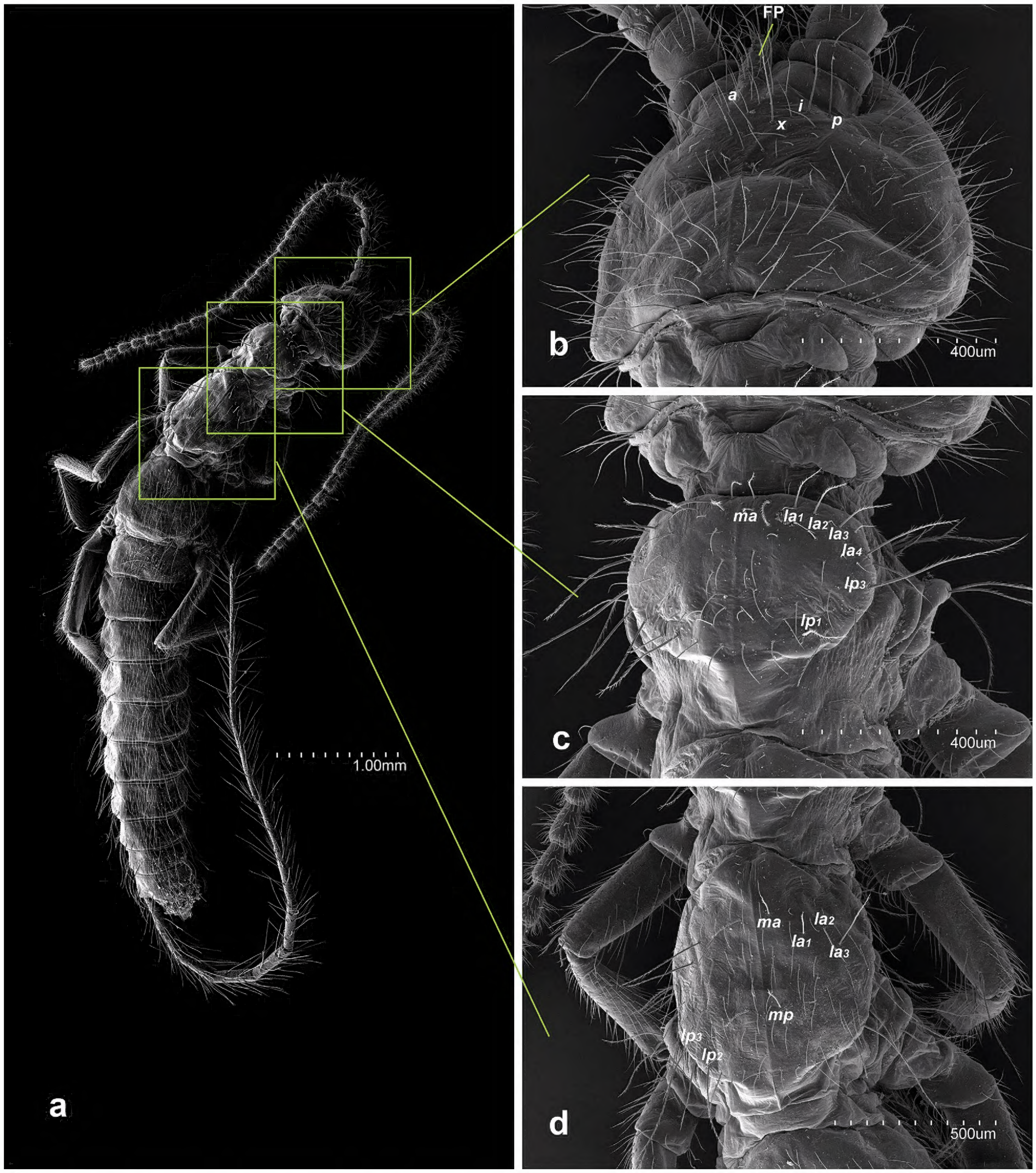

Figure 6. *Plusiocampa* (*Plusiocampa*) *bulgarica* Silvestri, 1931, with tuberculate frontal process, specimens AS coll.; **a.** Habitus; **b.** Head, dorsal side; **c.** Pronotum; **d.** Mesonotum. (FP) frontal process; macrosetae (*a*) anterior, (*i*) intermediate, (**p**) posterior, (*x*) x setae on frontal head. Thoracic macrosetae (*ma*) medial anterior; (*la1*) lateral anterior 1: (*la2*) lateral anterior 2; (*la3*) lateral anterior 3; (*la4*) lateral anterior 4; (*mp*) medial posterior; (*lp3*) lateral posterior 3.

7+7, urosternites II–VII with 5+5, urosternite VIII with 2+2 macrosetae; stylus setae with a few barbs (Fig. 8e); typical exertile vesicles (Fig. 8e, f). Male with a large area of glandular g_1 setae and enlarged appendages with glandular a_1 setae (Fig. 9a); female with subcylindrical appendages with glandular a_1 setae (Fig. 9b, c).

Habitat and distribution. A cave-adapted species, which is found in a high number of caves in the studied area. This species appears to be common in the Rhodopes, Pirin, the central parts of the Balkan Mountains, and the Predbalkan. In the Rhodopes, *P. bulgarica* is distributed throughout the region, and in the present study, it was recorded for the first time in the eastern part, in the region of Dzhebel. However, so far it has not been recorded in the lower, warmer parts of East Rhodopes. In Pirin, the species inhabits caves above 2000 m above sea level, and also in

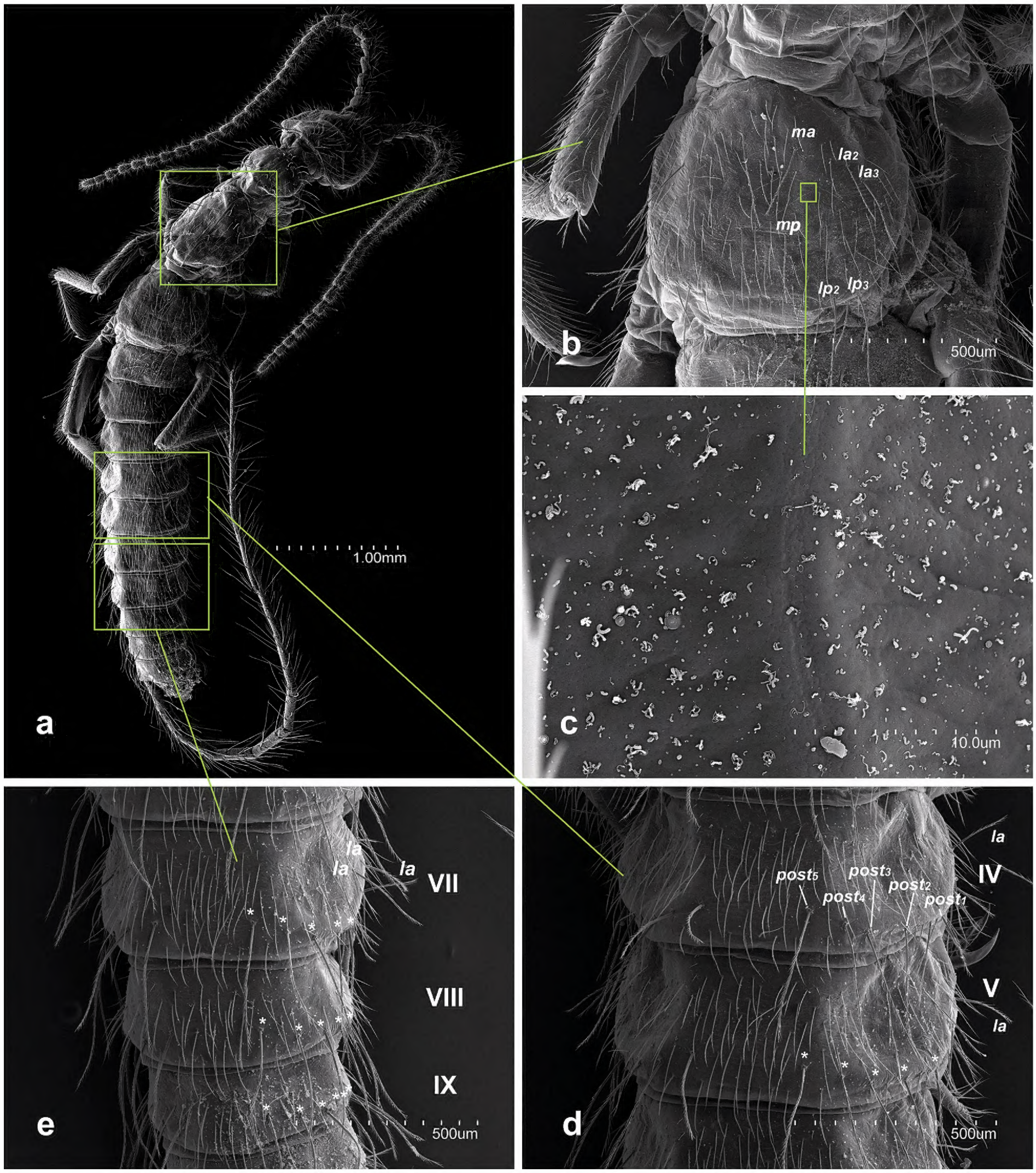

Figure 7. *Plusiocampa* (*Plusiocampa*) *bulgarica* Silvestri, 1931, with tuberculate frontal process, specimens AS coll.; **a.** Habitus; **b.** Metanotum; **c.** Detail epicuticle, at high magnifications; **d.** Posterior portion of the urosternite VI to anterior portion of abdominal X segment; **e.** Posterior portion of urotergite III to anterior portion of urosternite VI. Thoracic macrosetae (*ma*) medial anterior; (*la2*) lateral anterior 2; (*la3*) lateral anterior 3: (*mp*) medial posterior; (*lp2*) lateral posterior 2; (*lp3*) lateral posterior 3. Urotergal macrosetae (*la*) lateral anterior; (*post1*) posterior macrosetae 1; (*post2*) posterior macrosetae 2; (*post3*) posterior macrosetae 3; (*post4*) posterior macrosetae 4; (*post5*) posterior macrosetae 5; * Asterisk position of macrosetae.

the Western and Central Rhodopes many of the localities are above 1000 m, which clearly shows that the species is cold-resistant. There are only two records of the species in Predbalkan and one in Central Stara Planina Mts. It is worth mentioning that some populations, particularly those of caves Boevskata and Skoka, and the caves in Pirin Mts. have non-protruding setae on frontal process in contrast to all other tuberculated setae populations (Fig. 21).

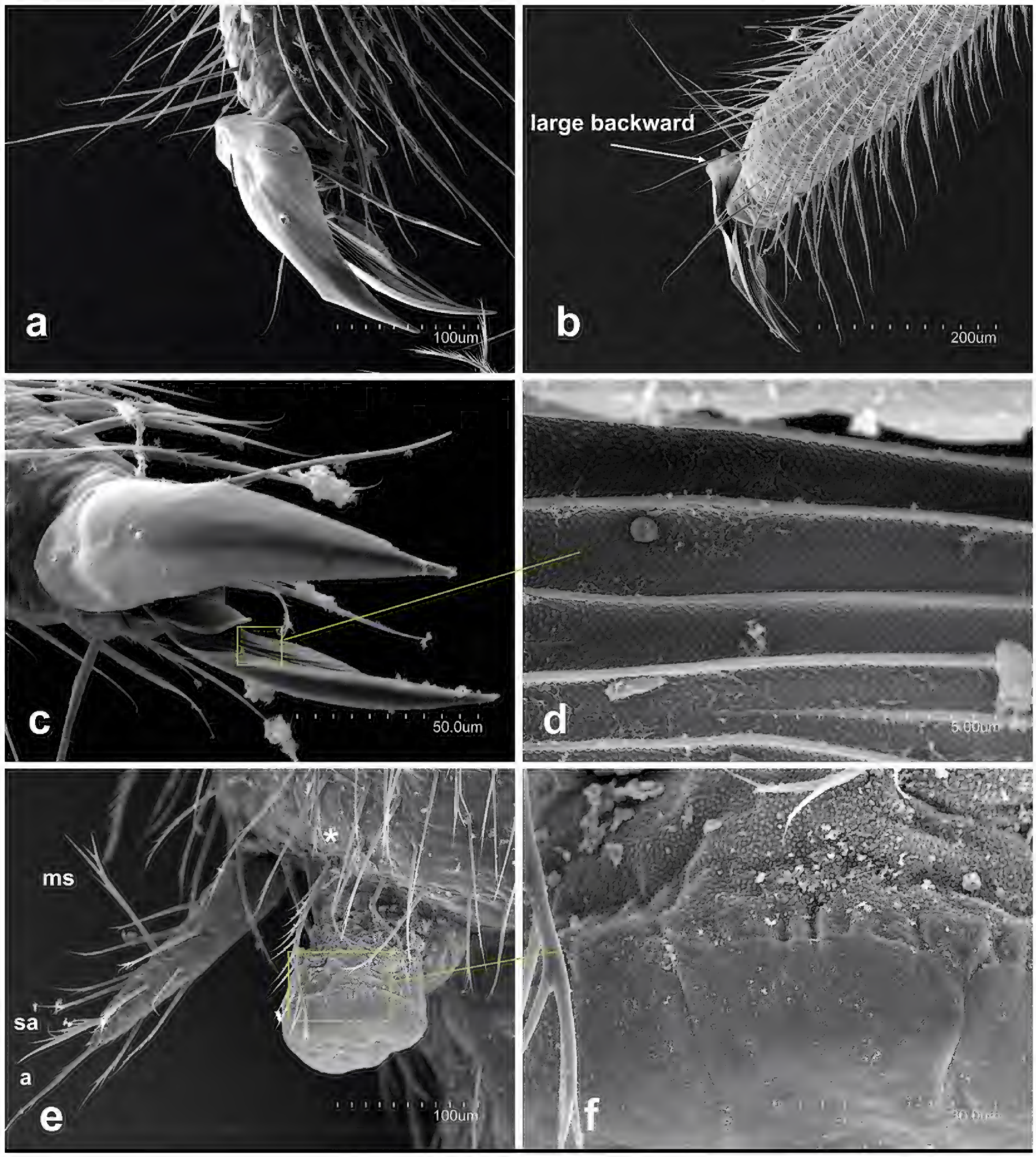

Figure 8. *Plusiocampa* (*Plusiocampa*) *bulgarica* Silvestri, 1931, with tuberculate frontal process, specimens AS coll.; **a.** End of tarsus and pretarsus of metathoracic leg, latero-posterior side; **b.** End of tarsus and pretarsus of metathoracic leg, latero-anterior side; **c.** End of tarsus and pretarsus of metathoracic leg, dorsal side; **d.** Detail of grooves on the ventral side of the claws in a metathoracic leg.; **e.** Latero-posterior portion of urosternite VII with the exertile vesicle and the stylus; **f.** Detail of exertile vesicle. * Asterisk position of macrosetae. (*sm*) sterno-medial seta; (*sa*) subapical seta; (*a*) apical seta on stylus.

Plusiocampa (*Plusiocampa*) *isterina* Condé, 1993

Figs 10, 21

Plusiocampa isterina Condé, 1993: 736, figs 1a, 2, 3a, 4, 6a. Type locality: Movile cave, Mangalia, Romania.

New material examined. Bulgaria: Shumensko Plateau: Shumen District • 3 males, Nahodka 13 Cave, 28 Sep. 1996, leg. P. Beron (male with enlarged appendages with a1, st I with g1) • 4 ex., Cave Zandana, 16 Jul. 1980, leg. P. Beron; Strandzha Mts. • 1 male, Burgas District, Village Stoilovo, Peshterata s dvata vhoda (cave), 24 Jun. 1980, P. Beron, S. Andreev leg.

Diagnosis. (Condé 1993, 1996; Sendra et al. 2020b): Elongated body. Epicuticle smooth under optical microscope. Antennae with 23–25 antennomeres; four simple

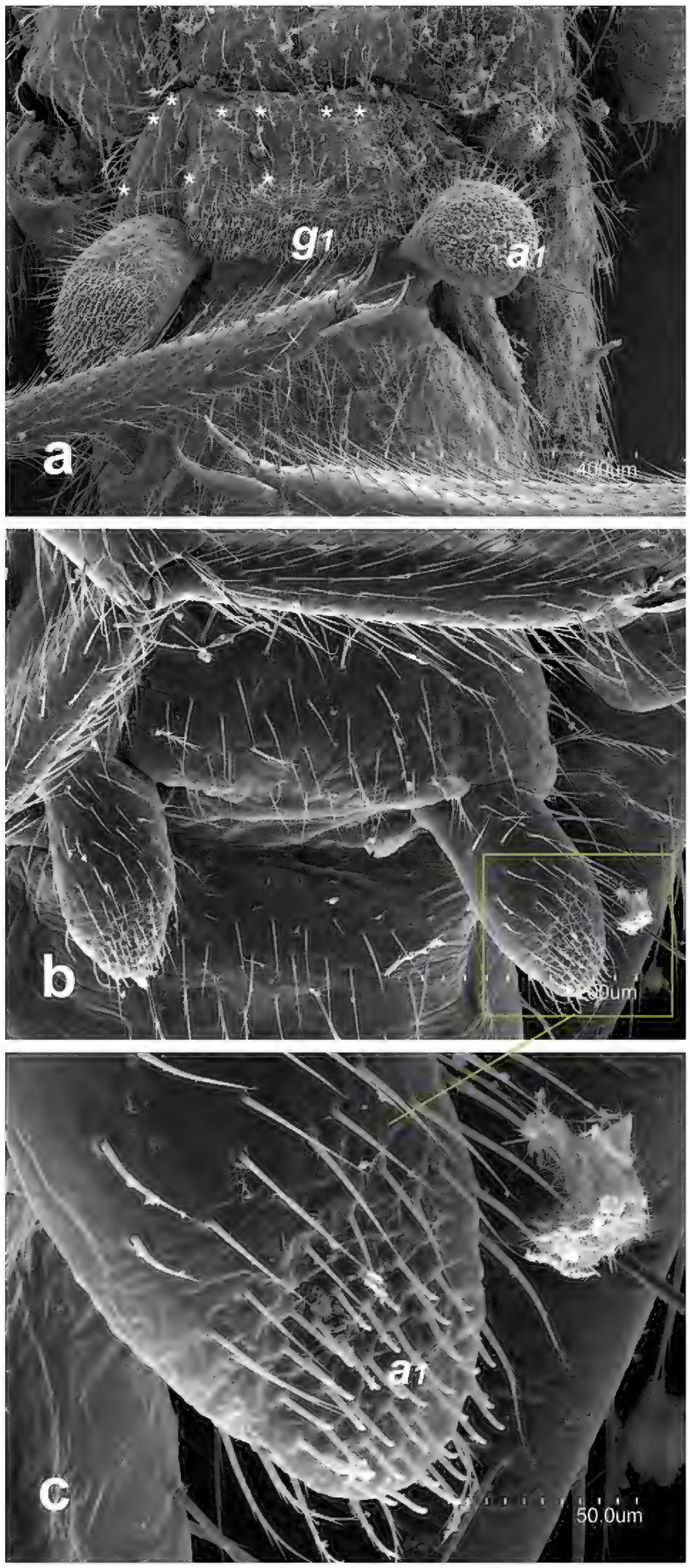

Figure 9. *Plusiocampa* (*Plusiocampa*) *bulgarica* Silvestri, 1931, with tuberculate frontal process, specimens AS coll.; **a.** Posterior portion of metasternum, urosternite I, and anterior portion of urosternite II, including tarsus of metathoracic legs of a male; **b.** Urosternite I and anterior portion of urosternite II, including tarsus of metathoracic legs of a female; **c.** Distal portion of appendage of urosternite I of a female. * Asterisk position of macrosetae. Urosternites I (*a1*) glandular setae a1; (*g1*) glandular setae g1.

olfactory chemoreceptors in cupuliform organ; slightly protruding frontal process with some slightly tubercular setae. Pronotum with 1+1 *ma*, 3+3 *la*, 2+2 *lp* macrosetae; mesonotum with 1+1 *ma*, 3+3 *la*, 2+2 *lp* macrosetae; metanotum with 1+1 *ma*, 1+1 (2+1) *la*, 2+2 *lp* macrosetae; long,

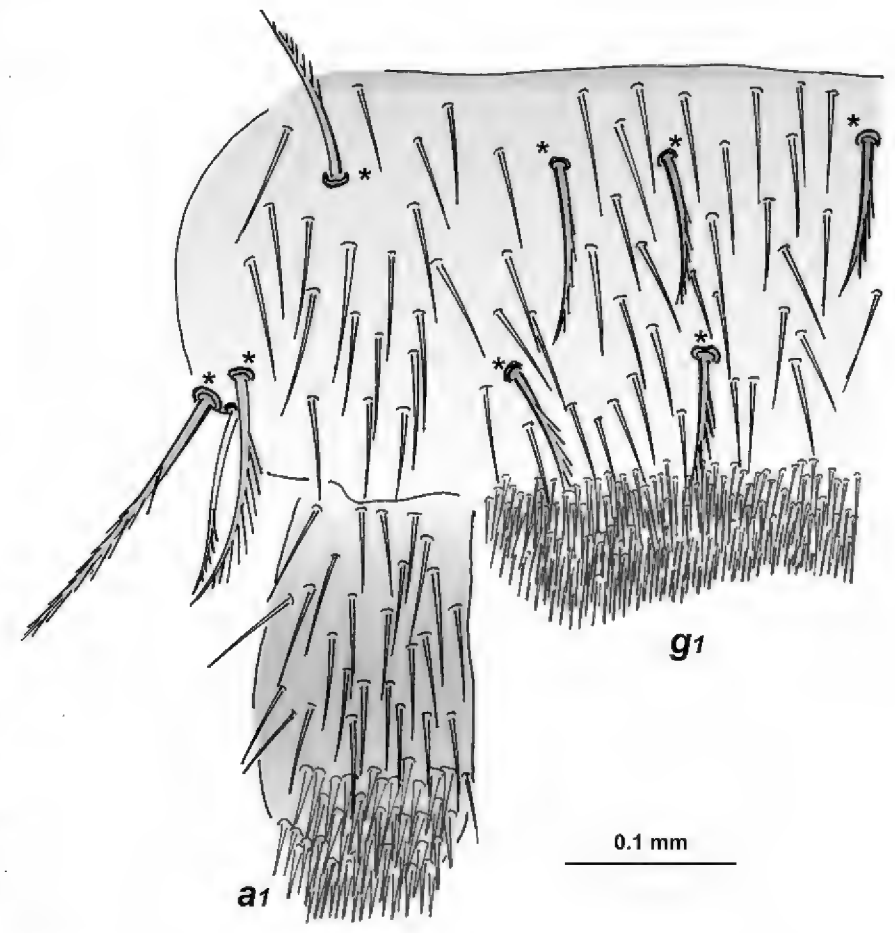

Figure 10. *Plusiocampa* (*Plusiocampa*) *isterina* Condé, 1993; first urosternite of a male. * Asterisk position of macrosetae. Urosternites I (*a1*) glandular setae a1; (*g1*) glandular setae g1.

thin, barbed notal macrosetae; short, smooth clothing setae. Two ventral tibial macrosetae; unequal claws (1.3) with large lateral crests, posterior claw with a backward overhang; pretarsal processes short, with a few sparse barbs. Urotergites I–II with 1+1 *post* macrosetae; urotergite III with 2+2 *post* macrosetae; urotergites IV–V with 1+1 *la*, 5+5 *post* macrosetae; urotergites VI–VII with 2+2 *la*, 5+5 *post* macrosetae; urotergite VIII with 6+6 *post* macrosetae; abdominal segment IX with 8+8 *post* macrosetae; urosternite I with 7+7, urosternites II–VII with 5+5, urosternite VIII with 2+2 macrosetae; first urosternite of male with a large field of up to 302 glandular g_1 setae on the posterior portion and supporting subcylindrical large appendages bearing a field of up to 43 glandular a_1 setae (Fig. 10); first urosternite in female with subcylindrical female appendages bearing glandular a_1 setae.

Habitat and distribution. Non-troglomorphic species. Until now, the species was known only from Peştera Movile in Southern Dobruja, Romania. Here, we report it for the first time from Bulgaria, based on specimens found in two caves on the Shumen Plateau and one in the Strandzha Mountains. Additionally, Sendra et al. (2020) reported seven specimens of *Plusiocampa* (*Plusiocampa*) aff. *isterina* found in Ledenjača Cave, Bosnia and Herzegovina. These specimens were distinguished from the typical form by a higher number of antennomeres (25–28), the presence of six olfactory chemoreceptors in a relatively large cupuliform organ (occupying one-third of a short antennomere), and a more prominent frontal process bearing distinctive tuberculate setae.

It is interesting that two species of Diplura are recorded in the Zandana cave – *P. arbanisiensis* and *P. isterina*. Future research will show whether these are indeed different species or whether the material is misidentified (Fig. 21).

Plusiocampa (*Plusiocampa*) *lindbergi* Condé, 1956

Fig. 21

Plusiocampa (*Plusiocampa*) *lindbergi* Conde, 1956: 7, figs 1, 2. Type locality: Saint-Jean-le Prodrome cave, Serres District, Greece.

Material examined. Greece: Menikio Mts. • 1 ex., Timiou Prodromou Monastery, 11 km NE from Serres, cave Piladele (Saint-Jean-le Prodrome), 490 m alt., in guano, 19 Mar. 2010, leg. B. Petrov; Thasos Island • 1 ex., Skalo Rachoniou, unnamed cave 40.78384°N, 24.62212°E, 07 Sep. 2010, leg. B. Petrov.

Diagnosis. (Condé 1956; Sendra et al. 2020b): Slightly troglomorphic species. Antennae with 34–37 antennomeres; five olfactory chemoreceptors in cupuliform organ of a possibly regenerated antenna; non-protruding frontal process with non tuberculate setae. Pronotum with 1+1 *ma*, 4+4 *la*, 2+2 *lp* macrosetae; mesonotum with 1+1 *ma*, 2+2 *la*, 2+2 *lp* macrosetae; metanotum with 1+1 *ma*, 2+2 *lp* macrosetae; long, large, barbed notal macrosetae; smooth clothing setae. Two ventral tibial macrosetae; subequal claws (1.05–1.1) with middle-sized lateral crests, posterior claw with no backward overhang. Urotergites I–III with 1+1 *post* macrosetae; urotergite IV with 1+1 *la*, 2+2 *post* macrosetae; urotergites V–VII with 1+1 *la*, 4+4 *post* macrosetae; urotergite VIII with 6+6 *post* macrosetae; abdominal segment IX with 8+8 post macrosetae; urosternite I with 7+7, urosternites II–VII with 5+5, urosternite VIII with 2+2 macrosetae. Male with narrow area of glandular g_1 setae, enlarged subcylindrical appendages with up to 60 glandular a_1 setae; female with slender, subcylindrical appendages.

Habitat and distribution. Subterranean species, known from Saint-Jean-le-Prodrome Cave (Spilaio Pelade) and from Mesovoid Shallow Substratum (MSS) near Xánthi, in the Macedonian region of Greece. Here, we report the species also from a cave on Thasos Island, which is not surprising given its close proximity to the mainland (Fig. 21).

Plusiocampa (*Plusiocampa*) *balcanica* Sendra & Stoev, sp. nov.

https://zoobank.org/1A93AF14-6A9B-4C1C-96E0-8946316D8FBB

Figs 11, 12, 21

Etymology. The specific epithet derives from the type locality, which is situated in Stara Planina (= Balkan) Mts. The specific epithet is a noun in the genitive case.

Material examined. ***Holotype*** • male deposited in the Natural History Museum of Sofia, Non-insect Invertebrates – Id. 10835 NMNHS. Bulgaria: Central Stara planina Mts.: Karlovo District, village Hristo Danovo, cave Yulen Ere (Vodnata peshtera), 950 m alt., 27 Sep. 1997, leg. P. Beron & T. Ivanova; ***Paratypes*** • 3 females from the same locality, date, and collectors deposited in the Natural History Museum of Sofia, Non-insect Invertebrates Id. 10836-10838 NMNHS • 1 female from the same locality, date, and collectors deposited in MCNB-MZB 2025-7269; and 1 male from the same locality, date, and collectors deposited in MUVHN-ZE4330.

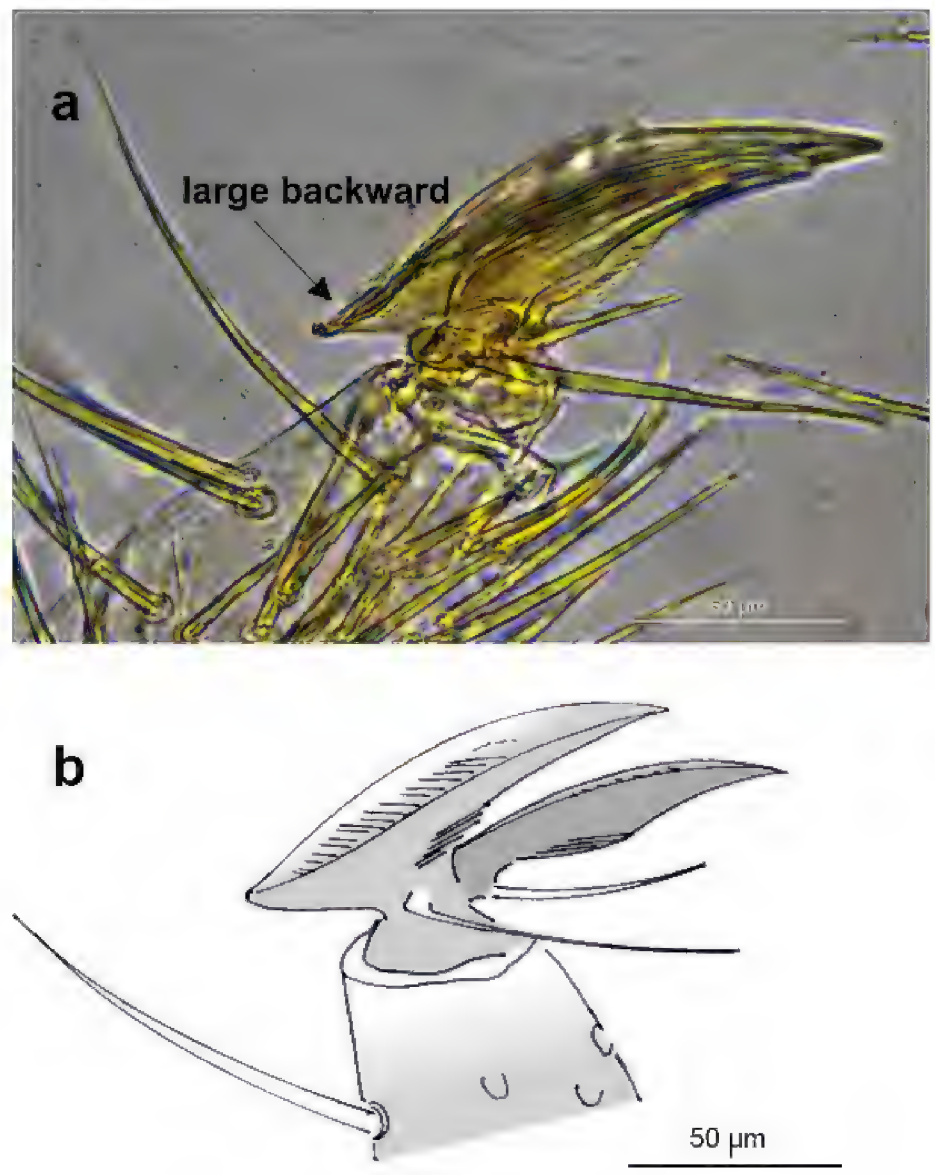

Figure 11. *Plusiocampa* (*Plusiocampa*) *balcanica* Sendra & Stoev, sp. nov. holotype male, code 10835 NMNHS; **a.** Pretarsus metathoracic leg of the; **b.** Outline of the (**a**) pretarsus.

Description. ***Body.*** Body length 5.5 mm and 6-mm (holotype) males, 6.5 mm to 7 mm females. Epicuticle smooth under optical microscope; slender body with smooth or with one or two tiny distal barbs on clothing setae.

Head. Antennae have 37, 40, 40, and 41 antennomeres in four completed and intact antennae; antennae ~1.1–0.7 times longer than the body's length, with medial antennomeres almost three times longer than wide and apical antennomere more than two times longer than wide. Cupuliform organ, occupying 1/9 of the total length in the last antennomere, has about 6–7 complex olfactory chemoreceptors. Distal and central antennomeres have two whorls of macrosetae with a few distal barbs and scattered smooth thin setae, in addition to a single distal whorl of 10–14 long gouge sensilla (35–45 µm long) and up to two very short coniform sensilla. Proximal antennomeres have typical trichobothria, plus a small coniform sensillum on the third antennomere in ventral position. The frontal process has three slightly tuberculate smooth macrosetae; the three-insertion line macrosetae with a few distal barbs, with length ratios of *a/i/p/x* are 41/47/35/55, respectively, in the holotype. Labial palps are suboval with small latero-external sensillum, three guard setae, up to six setae on the anterior border, and up to 95 neuroglandular setae in the larger paratype.

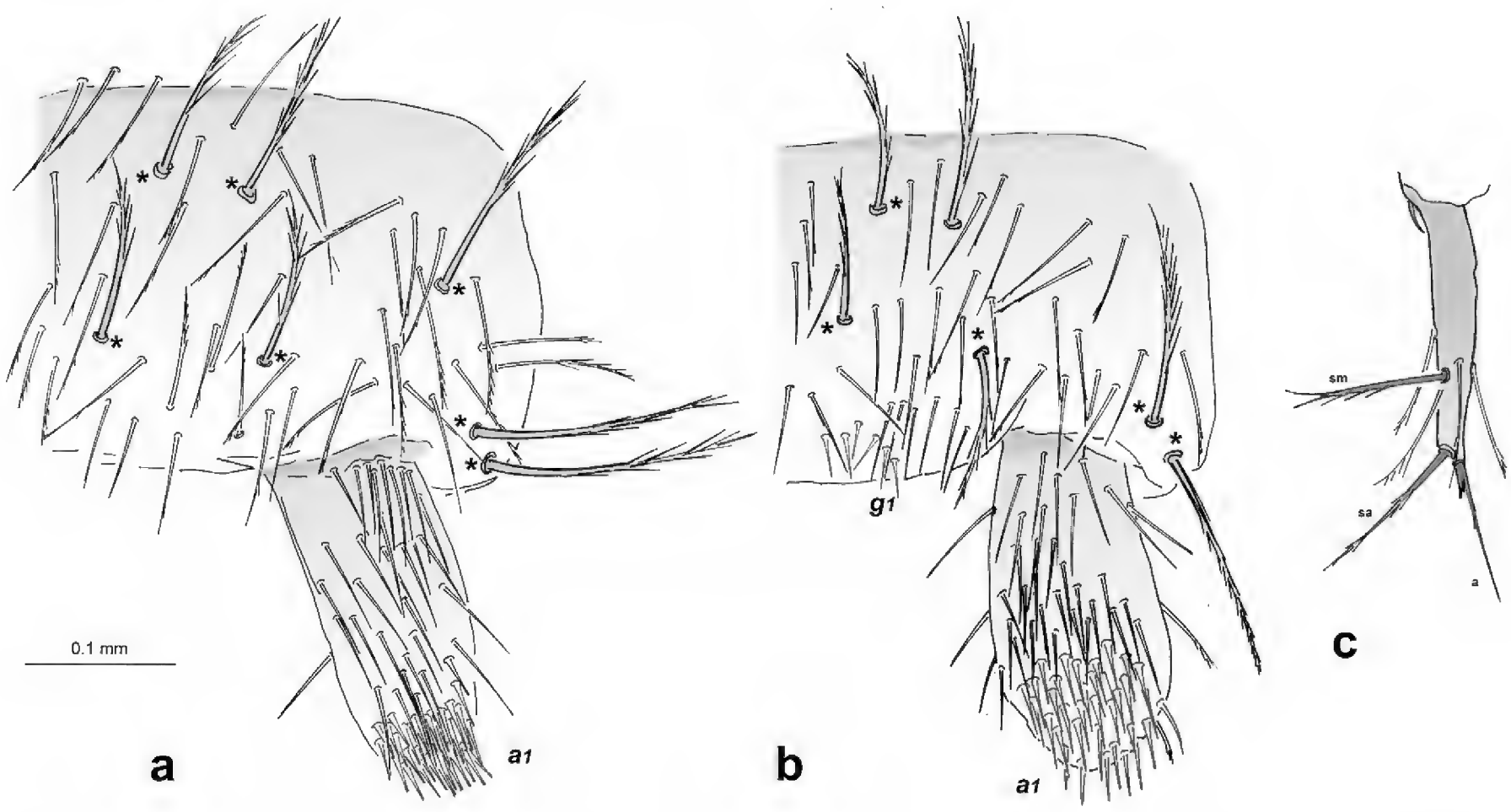

Figure 12. *Plusiocampa* (*Plusiocampa*) *balcanica* Sendra & Stoev, sp. nov.; **a.** First urosternite of the paratype female 7 mm, code Id. 10836 NMNHS; **b.** First urosternite of the holotype, code 10835 NMNHS; **c.** Stylus of the seventh urosternite of the paratype female 7 mm, code Id. 10836 NMNHS. * Asterisk position of macrosetae. Urosternites I (*a1*) glandular setae a1; (*g1*) glandular setae g1. (*sm*) sterno-medial seta; (*sa*) subapical seta; (*a*) apical seta on stylus.

Thorax. Thoracic macrosetae distribution: pronotum with 1+1 *ma*, 2+2 la_{3-4}, 1+1 $lp_{1, 3}$ macrosetae; mesonotum with 1+1 *ma*, 3+3 la_{1-3}, 2+2 lp_{2-3} and 1+1 *ma*, 1+1 la_{1}, 2+2 lp_{2-3} long macrosetae. All macrosetae long with thin barbs along the basal two−thirds of their length; thin marginal setae barbed on distal portion double the length of clothing setae. Legs elongated, and the metathoracic legs reach the eighth abdominal segment. Tibia longer than the femur or tarsus; femur/tibia/tarsus plus claws: 0.10/0.11/0.99 mm in paratype 7 mm in lengths. Femora I–III with one long dorsal macrosetae, and three ventral macrosetae on tibia III. Calcars have long barbs almost all over. Two ventral rows of slightly barbed on medial portion setae on tarsus; end part of the tarsus with two dorsal smooth long setae plus two ventral long barbed setae. Claws are very unequal in size with posterior claw longer than the anterior claw (1.6–1.8: ratio posterior/anterior). Claws have large lateral crests well developed in posterior claw with a large backward overhang. Pretarsus has similar long smooth setiform lateral processes on posterior claw but shorter on the smaller anterior claw (Fig. 11a, b).

Abdomen. Distribution of abdominal macrosetae on tergites: 1+1 *post* macrosetae on I–III (0+0 on I–II uroterg-ites in male paratype), 1+1 *la*, 5+5 *post* on IV–V uroterg-ites, 2+2 *la*, 5+5 *post* on VI–VII; 6+6 *post* on VIII, and 8+8 *post* macrosetae on IX abdominal segment. All tergal abdominal macrosetae long and well-differentiated with thin barbs along most of its length. Urosternite I with 7+7 (7+1+7) well-barbed macrosetae (Fig. 15a, b); urosternites II to VII with 5+5 macrosetae; urosternite VIII with 2+2 macrosetae; urosternal macrosetae with long barbs along distal half to two third. Stylus with an apical almost smooth setae with one large and one small basal barb, subapical seta with a few short barbs and ventromedial seta with some long barbs on half distal part (Fig. 12c). All cerci broken, the most complete is 4.8 mm long with a basal article follow for eight primary articles; each primary article bear up to four untidy whorls of macrosetae with short thin barbs on half distal part in addition to several smooth long setae and the characteristic apical whorl of very thin short setae smooth or with one or two tiny barbs.

Secondary sex characters. Female urosternite I with large subcylindrical appendages, bearing each up to 30 glandular a_{1} setae in a distal field (Fig. 12a). Male with larger subcylindrical appendages than the female, bearing each up to 45 glandular setae a_{1}, in addition posterior portion of the urosternite with a few glandular g_{1} setae, up to 14 on holotype (Fig. 12b) with bears a whorl of 17 short setae around the terminal hole of the genital papilla.

Taxonomic position. According to Sendra et al. (2020b), the taxonomy of the species of *Plusiocampa* needs thorough revision and clarification. However, here we propose a new species: *Plusiocampa* (*Plusiocampa*) *balcanica* sp. nov., which is distinguished from the congeners (*Plusiocampa* s.str.) by having two reliable taxonomic characters: very uneven pretarsal claws with a 1.6–1.8: posterior/anterior ratio, and the lack of medial posterior macrosetae on the mesonotum and metanotum. There is yet another species that possesses this combination of characters: *Plusiocampa* (*Plusiocampa*) *ternovensis* Sendra & Borko, 2020, found in three caves on the

edge of a karst plateau north of the town of Ajdovščina, in Slovenia (Sendra et al. 2020b).

However, *P.* (*P.*) *balcanica* sp. nov. can be distinguished from *P.* (*P.*) *ternovensis* by the following characters: 2+2 *la* macrosetae on the pronotum (vs. 4+4 in *P.* (*P.*) *ternovensis*; three ventral tibial macrosetae (vs. only one); 5+5 post macrosetae on urosternites V–VII (vs. 4+4); and larger, thicker appendages in both males and females (vs. much thinner ones in *P.* (*P.*) *ternovensis*.

Habitat and distribution. This cave-adapted species is currently known only from a single cave, Yulen Ere (Vodnata Peshtera), near the village of Hristo Danovo in the Central Stara Planina Mts (= Balkan) in Bulgaria (Fig. 21). According to Beron (2015), the cave is situated at an altitude of 970 m and has a length of 227 m, with a denivelation of +17 m. In addition to *Plusiocampa* (*P.*) *balcanica* sp. nov., the following species have been recorded in the cave: Araneae: *Meta menardi* (Latreille, 1804), *Antrohyphantes balcanica* (Drensky, 1931); Pseudoscorpiones: *Chthonius* sp.; Diptera: *Triphleba antricola* (Schmitz, 1918); Chiroptera: *Rhinolophus ferrumequinum* (Schreber, 1774), *Rhinolophus hipposideros* (Bechstein, 1800) (Beron 2015). Two other caves, Zlatnata Peshtera and Mazata, are known from the same area. It is, therefore, likely that the new species also occurs in these caves.

Subgenus *Stygiocampa* Silvestri, 1934

Plusiocampa (*Stygiocampa*) *bureschi* Silvestri, 1931

Figs 13–17, 21

Plusiocampa bureschi Silvestri, 1931: 100, figs iii–v. Type locality: Temnata dupka, Lakatnik Railway Station, Bulgaria.

Plusiocampa (*Stygiocampa*) *rauseri* Rusek, 1965: 94, figs 18–24.

Plusiocampa (*Stygiocampa*) *bureschi*: Beron, 2015: 92.

New material examined. Bulgaria: Vrachanska Planina Mts • 2 ex., Svoge Ditstrict, Lakatnik Railway Station, cave Razhishkata peshtera (type locality of *P. rauseri*), 28 Feb. 1993, leg. B. Petrov • 15 ex., same locality, 22 Feb. 1995, leg. B. Petrov • 3 ex., Svoge Ditstrict, Lakatnik Railway Station, cave Kozarskata, 21 Mar. 1993, leg. P. Stoev • 3 ex., same locality, 03 Nov. 2010, leg. B. Petrov, N. Toshkova • 1 ex., Svoge Ditstrict, Lakatnik Railway Station, cave Svinskata dupka, 450 m, alt., 19 Apr. 2006, leg. B. Petrov • 1 ex., same locality, 03 Nov. 2010, leg. B. Petrov, N. Toshkova • 3 ex., Mezdra District, Cherepish Railway Station, cave Novata pestera, 43.09811°N, 23.59615°E, 562 m alt., 01 Jun. 2012, leg. N. Toshkova • 3 ex., Mezdra District, Cherepish Railway Station, cave Serapinovata peshtera, 15 Apr. 1993, leg. P. Stoev • 1 ex., Mezdra District, Cherepish Railway Station, cave Ezeroto, 03 Feb. 2008, leg. Y. Makulev, Zh. Zhechev • 4 ex., Sofia District, village Iskrets, cave Tsarkvishte, 14 Nov. 1993, leg. B. Petrov • 1 ex., Sofia District, village Breze, cave Yamata, 1000 m alt., 20 Jun. 1993, leg. B. Petrov • 1 female, Sofia District, village Tserovo, cave Vodnata peshtera, 09 May. 1982, leg. P. Beron • 2 ex., Vratsa District, village Chelopek, cave Dedova dupka, alt. 885 m alt., 23 Sep. 2017, leg. K. Lakovski, O. Genova • 1 male, 1 female, same locality, and collectors, 03 Nov. 2017.

Diagnosis. (Silvestri 1931; Condé 1956, 1959; Condé and Bareth 1996; Bareth and Condé 2001): Epicuticle with a surface in strips in anastomosis unions visible at high magnifications, not visible in optical microscope (Fig. 14a). Antennae with 39–54 antennomeres elongated with up to 32 thin gouge sensilla on medial antennomers, covered by up to 5 whorls of macrosetae (Fig. 13c, d); base of the trichobothria elevated overpassing the surface (Fig. 13b); seven to nine complex olfactory chemoreceptors in cupuliform organ, each with a prominent central protrusion surrounding a single fold (Fig. 13a). Labium subtriangular with the typical latero-anterior bacilliform sensillum in addition to a field of about 120 thin gustative glandular sensilla (Fig. 14b). Pronotum with 1+1 *ma*, 2+2 *la*, 2+2 *lp* macrosetae; mesonotum with 1+1 *ma*, 1+1 *lp* macrosetae; metanotum without macrosetae; long, barbed notal macrosetae; abundant notal clothing setae. No ventral tibial macrosetae; slightly unequal claws (1.1–1.3: ratio posterior/anterior) with large and narrow lateral crests, posterior claw with a small backward overhang (Fig. 15a–e); calcars all covert with numerous long barbs (Fig. 15f). Urotergite VII with 2+2 *post* macrosetae; urotergites VIII with 4+4 *post* macrosetae; abdominal segment IX with 6+6–7+7 *post* macrosetae; urosternite I with 7+7, urosternites II–VII with 5+5, urosternite VIII with 2+2 macrosetae (Fig. 16c–f); stylus setae all covered with numerous long barbs (Fig. 17a, b); typical exertile vesicles (Fig. 17c, d). Male without glandular g_1 setae, long subcylindrical slightly enlarged appendages with glandular a_1 setae; female with very long subcylindrical appendages with glandular a_1 setae (Fig. 16a, b). Spermatozoid fascicles 50 µm in diameter, 25 µm wide; wheels with 3½ turns of 300–350 µm and 5.6 µm diameter filament.

Habitat and distribution. The species seems highly adapted to the cave environment, and until now, it has been known from 11 caves in the area surrounding Tserovo and Lakatnik railway stations (Beron 2015). With the present study, its range has expanded by approximately 14 km (in a straight line) to the west-southwest, where it has been recorded in caves near the villages of Breze and Iskrets, and by about 18 km to the north-northeast, where it has been found in three caves in the area of Cherepish railway station and the village of Chelopek. All recorded locations are within the karst region of the Vratsa Mountain, one of the most cave- and cave-organism-rich areas in the country (Fig. 21).

Plusiocampa (*Stygiocampa*) *petrovi* Sendra & Stoev, sp. nov.

https://zoobank.org/F659928B-91C9-4136-9077-B26323E0A563

Figs 18–21

Etymology. We name this species after the late colleague and friend Boyan Petrov, a zoologist at the National Mu-

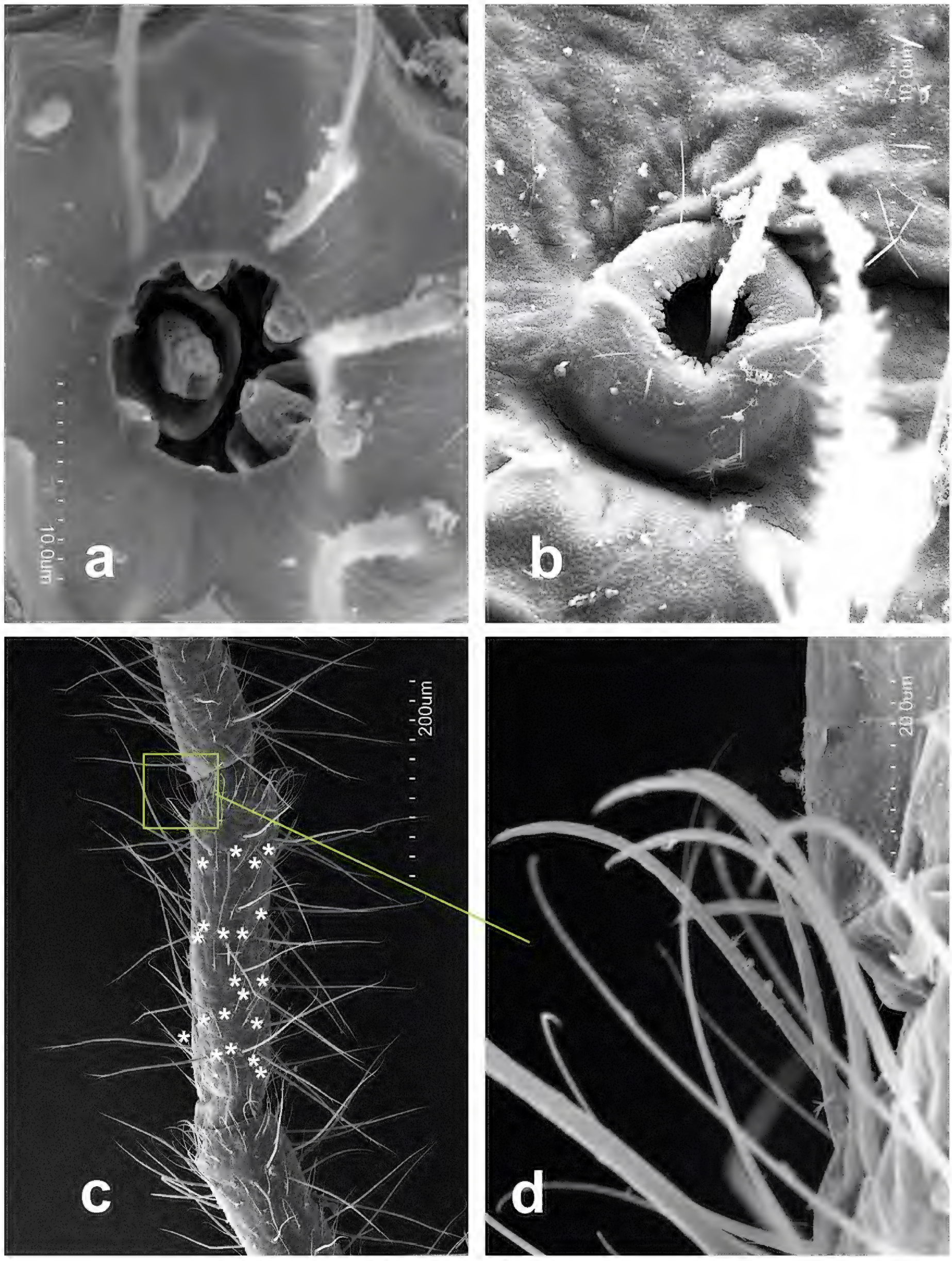

Figure 13. *Plusiocampa* (*Stygiocampa*) *bureschi* Silvestri, 1931; specimens AS coll. **a.** Cupuliform organ; **b.** Trichobothrium; **c.** Medial antennomeres; **d.** Gubia sensilla. * Asterisk position of macrosetae.

seum of Natural History in Sofia, who collected most of the material studied in this publication. The specific epithet is a noun in the genitive case.

Material examined. ***Holotype*** • female deposited in the Natural History Museum of Sofia, Non-insect Invertebrates –Id. 10839 NMNHS. Bulgaria: Vrachanska Plani-

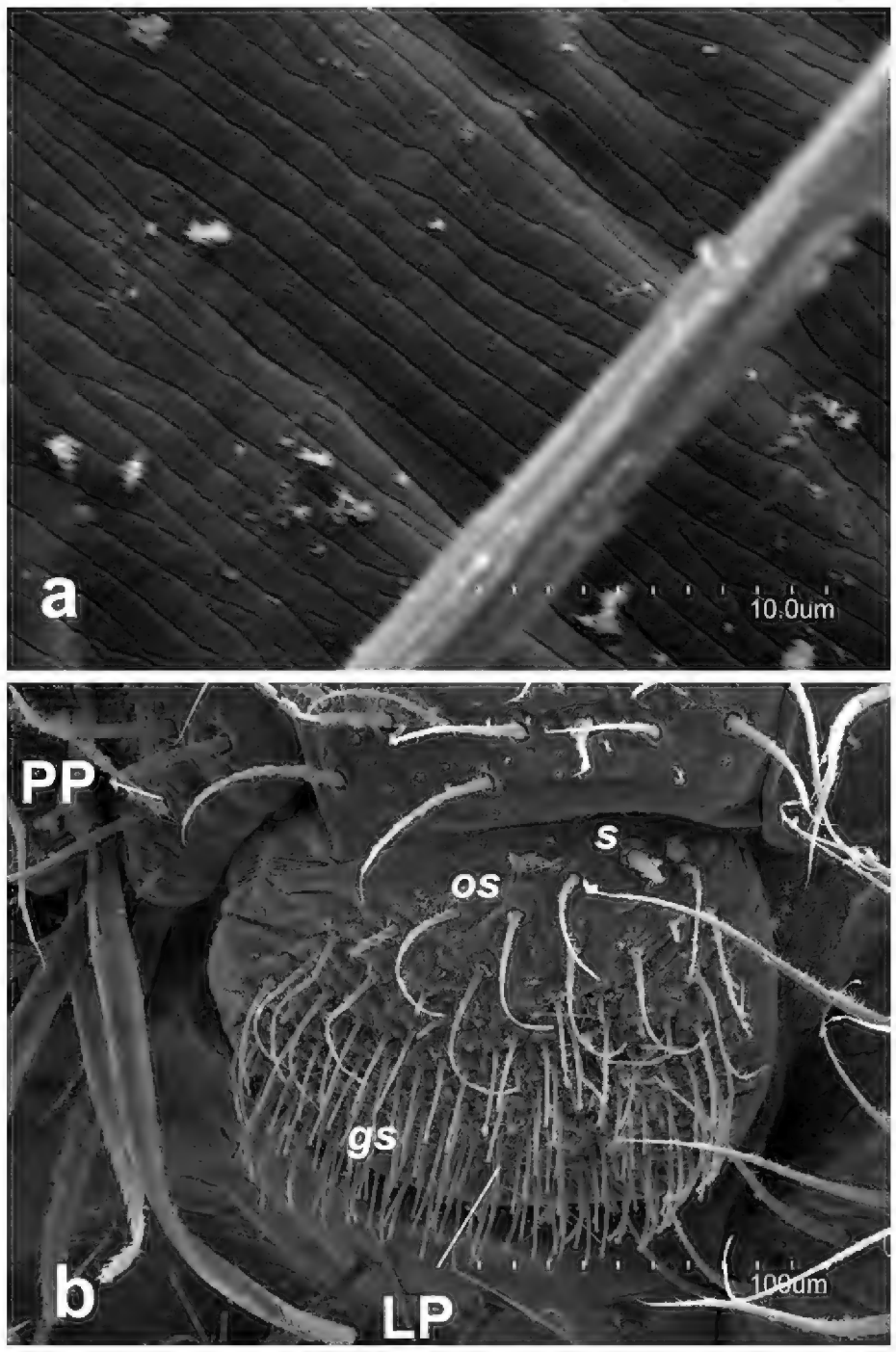

Figure 14. *Plusiocampa* (*Stygiocampa*) *bureschi* Silvestri, 1931; specimens AS coll. **a.** Surface of notal cuticle; **b.** Labial palp. PP palpiform process. LP Labial palp. (s) sensilium; (os) ordinary setae; (gs) gustative glandular setae.

na Mts.: Vrachanski Balkan Natural Park, Vratsa District, Village Pavolche, Cave Pukoya, 750 m alt., 43.16261°N, 23.58883°E, clay, 03 Jul. 2010, leg. S. Goranov leg.

Description. ***Body.*** Body length 5.8 mm female holotype. Epicuticle smooth under optical microscope (Fig. 21a); slender body with barbed clothing setae along distal two–thirds of each seta.

Head. Antennae with 41 antennomeres in one completed and intact antenna; antennae, 7 mm long, are approximately ~1.2 times longer than the body's length, with medial antennomeres almost four times longer than wide and apical antennomere three times longer than wide. Cupuliform organ occupying 1/9 of total length in the last antennomere has about eight complex olfactory chemoreceptors. Distal and central antennomeres have four to five untidy whorls of smooth macrosetae and scattered smooth setae, in addition to a single distal whorl of 18–20 long gouge sensilla (35–40 µm long) and up to two very short coniform sensilla 10–12 µm long. Proximal antennomeres with typical trichobothria, plus a small coniform sensillum on the third antennomere in ventral position. Frontal process has non protrusion with clothing setae and a couple of smooth long macrosetae, slightly longer than the three-insertion line macrosetae, with length ratios of *a/i/p/x* are 21/25/19/19, respectively, in the holotype (Fig. 18a). Labial palps are suboval with small latero-external sensillum, two guard setae, up to six setae on anterior border, and up to 95 neuroglandular setae in the holotype.

Thorax. Thoracic macrosetae distribution (Fig. 19a): pronotum with 1+1 *ma*, 1+1 la_3, 1+1 lp_1 macrosetae; mesonotum with 1+1 *ma* macrosetae; metanotum without macrosetae. All macrosetae relatively thin, long, and with thin barbs along the basal half to two–thirds of their length; thin marginal setae are also thin, barbed, and double the length of the clothing setae. Legs elongated, and the metathoracic legs overpass 1/3 of their length at the end of the abdomen. Tibia longer than the femur or tarsus; coxa/trochanter/femur/tibia/tarsus plus claws: 0.18/0.1/1.05/1.15/0.5 mm. Femora I–III with no dorsal macrosetae, and no ventral macrosetae on tibia I-III. Calcars have small thin barbs all over, pubescence type. Two ventral rows of barbed setae on the medial portion of the tarsus; end part of the tarsus with two dorsal smooth long setae plus two ventral long barbed setae. Claws unequal in size, that is, the posterior claw longer than the anterior claw (1.3–1.4: ratio posterior/anterior). Claws with large lateral crests well developed in posterior claw with a large backward overhang. Pretarsus with similar, long, smooth and setiform lateral processes (Fig. 18b).

Abdomen. Distribution of abdominal macrosetae on tergites: 1+1 $post_5$ short macrosetae on VI, 2+2 $post_{4,5}$ on VII, 5+5 *post* on VIII; and 8+9 *post* on IX abdominal segment (fig. 22b). All tergal abdominal macrosetae long and well-differentiated with thin barbs along their length. Urosternite I with 8+8 well-barbed macrosetae (Fig. 20); urosternites II to VII with 5+5 macrosetae; urosternite VIII with 2+2 macrosetae; long and well-barbed urosternal macrosetae. Stylus with an apical, subapical, and ventromedial seta completely covered with thin barbs all around except at the ending part; apical seta shorter than the others. One apparently intact cercus respectively 1.1 times the body length; divided basal article followed by seven primary articles. Length of the cerci increases from proximal to distal articles (basal: five secondary articles 0.36 mm; 0.19 mm; 0.25 mm; 0.28 mm; 0.30 mm; and seven primary articles 0.33 mm; 0.38 mm; 0.40 mm; 0.40 mm; 0.55 mm; 0.90 mm; 1 mm; 0.90 mm). Each article with a variable number of untidy whorls of macrosetae with short, thin barbs on three/fourth of the distal part and some smooth setae. All primary articles with a distal whorl of longer covered with barbs macrosetae and a more distal whorl of short thin barbed setae.

Secondary sex characters. Female urosternite I with large coniform appendages, bearing each up to 30 glandular a_1 setae in a distal field (Fig. 20). Male unknown.

Taxonomic position. With the addition of *Plusiocampa* (*Stygiocampa*) *petrovi* sp. nov., the number of species in the subgenus *Stygiocampa* Silvestri, 1934, increases to nine. All are characterized by the absence of notal and urotergal macrosetae, while several species exhibit addi-

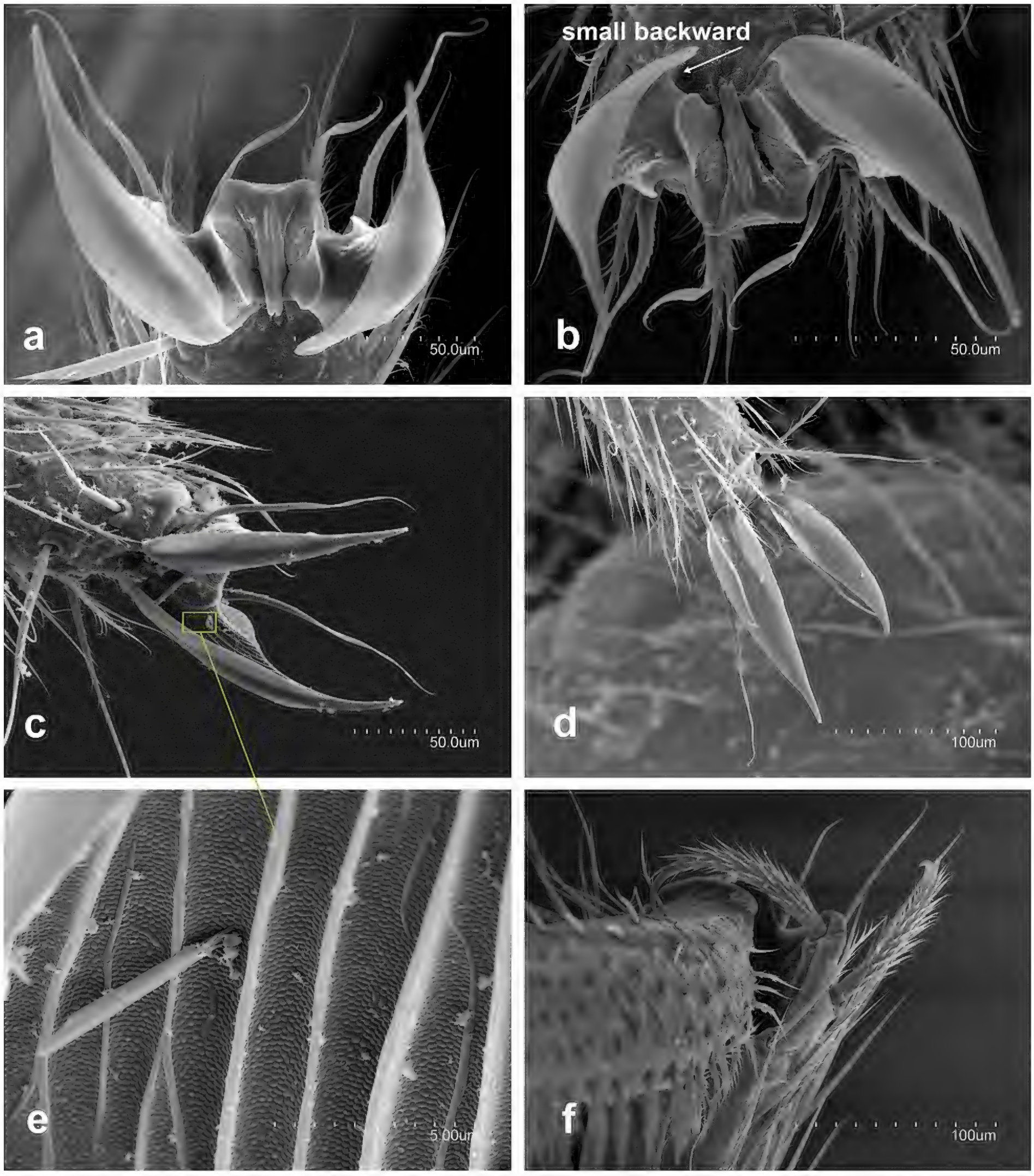

Figure 15. *Plusiocampa* (*Stygiocampa*) *bureschi* Silvestri, 1931, specimens AS coll.; **a.** Pretarsus metathoracic leg, frontal view; **b.** Pretarsus metathoracic leg, frontal view; **c.** Pretarsus metathoracic leg, dorsal lateral view; **d.** Pretarsus metathoracic leg, dorsal view; **e.** Detail ventral view of lateral crests; **f.** Calcars.

tional urosternal macrosetae: *Plusiocampa* (*Stygiocampa*) *nivea* (Joseph, 1882), *Plusiocampa* (*Stygiocampa*) *remyi* Condé, 1947, *Plusiocampa* (*Stygiocampa*) *dalmatica* Condé, 1959, *Plusiocampa* (*Stygiocampa*) *christiani* Condé & Bareth, 1996, and *Plusiocampa* (*Stygiocampa*) *barethae* Sendra & Rađa, 2021 (Joseph 1882; Condé 1947, 1959; Condé and Bareth 1996; Sendra et al. 2020b, 2021b). Among the *Stygiocampa* species, *P.* (*S.*) *bureschi*, *P.* (*S.*) *christiani*, and *P.* (*S.*) *petrovi* sp. nov. share a pronounced reduction in the number of both notal and urotergal macrosetae. Nevertheless, these species exhibit clear differences, such as the number of macrosetae on the pronotum (1+1 *ma*, 2+2-3+3 *la*, 1+1 *lp* in *P.* (*S.*) *christiani*; 1+1 *ma*, 2+2 *la*, 2+2 *lp* in *P.* (*S.*) *bureschi* and 1+1 *ma*, 1+1 *la*, 1+1 *lp* in *P.* (*S.*) *petrovi* sp. n.) and the number of *post* macrosetae on the seventh urotergite (0-1+1 *post* in *P.* (*S.*) *christiani*; 2+2 *post* in *P.* (*S.*) *bureschi* and *P.* (*S.*) *petrovi* sp. nov.). On the other hand, *P.* (*S.*) *petrovi* sp. nov.

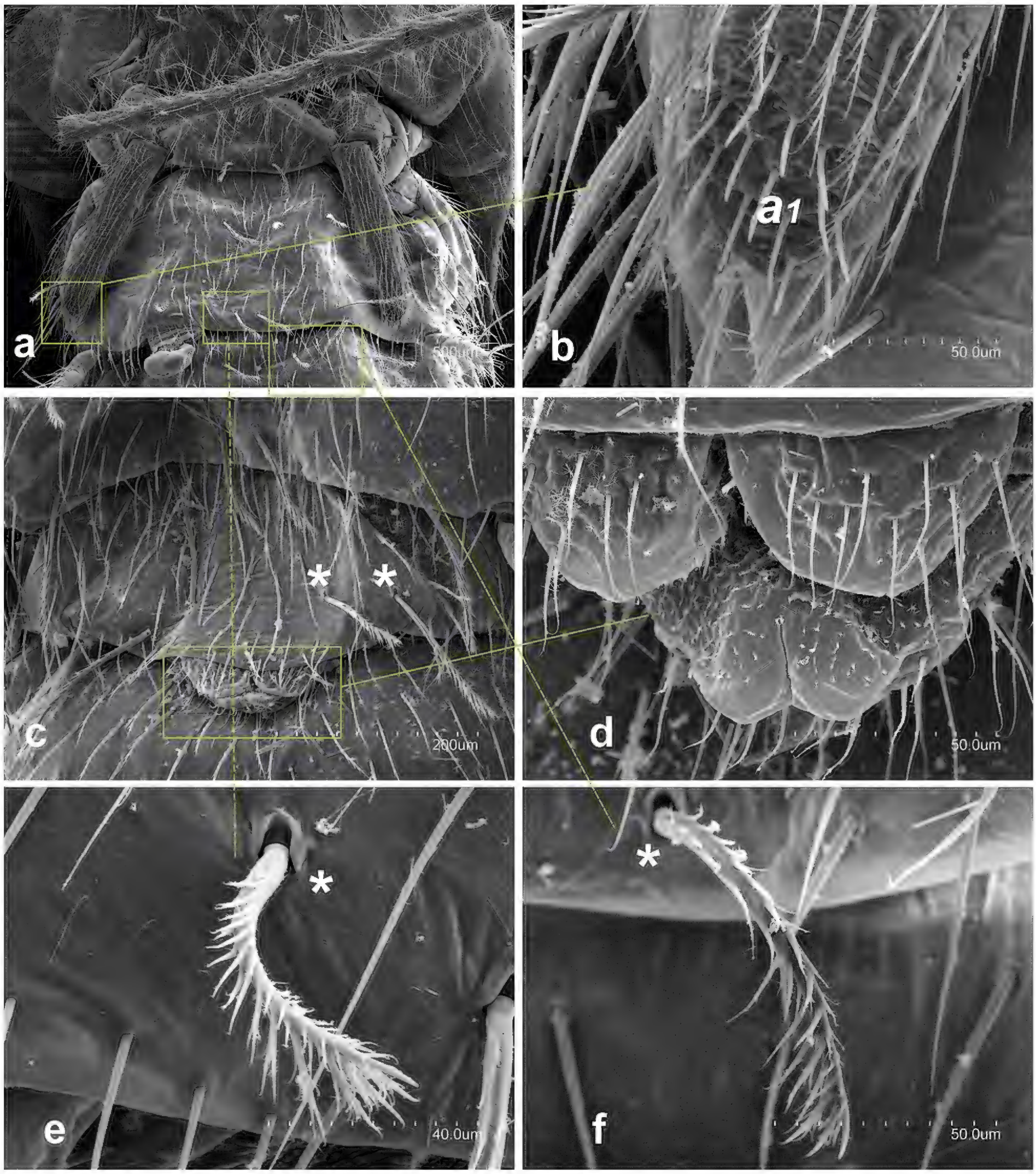

Figure 16. *Plusiocampa* (*Stygiocampa*) *bureschi* Silvestri, 1931, specimens AS coll.; **a.** First urosternite of a female; **b.** Detail of the apical portion of appendage in the first urosternite; **c.** Eighth urosternite; **d.** Female papilla; **e.** Urosternal macrosetae; **f.** Urosternal macrosetae. * Asterisk position of macrosetae. Urosternites I (*a1*) glandular setae a1.

has more unequal claws (with a 1.3–1.4: ratio posterior/anterior) than its geographically closest congener, *P.* (*S.*) *bureschi* (with 1.1: ratio posterior/anterior).

Habitat and distribution. Pukoya Cave is located in the Krushovitsa area near the village of Pavolche, Vratsa region, within the Vrachanski Balkan Nature Park. The cave is 48 meters long and 178 meters deep. It begins with a short, horizontal gallery, followed by two consecutive shafts; the second of these is approximately 15 meters deep. After that, the cave develops vertically. The middle sections are narrow, requiring ropes to reach the bottom, where water is present (Fig. 21).

In Beron's (2015) comprehensive monograph on Bulgaria's cave fauna, no organisms were reported from this cave. *Plusiocampa* (*Stygiocampa*) *petrovi* sp. nov. is the first species recorded in it. Notably, this new species was found in an area where another representative of the subgenus *Stygiocampa*, *P. bureschi*, is also present. The latter

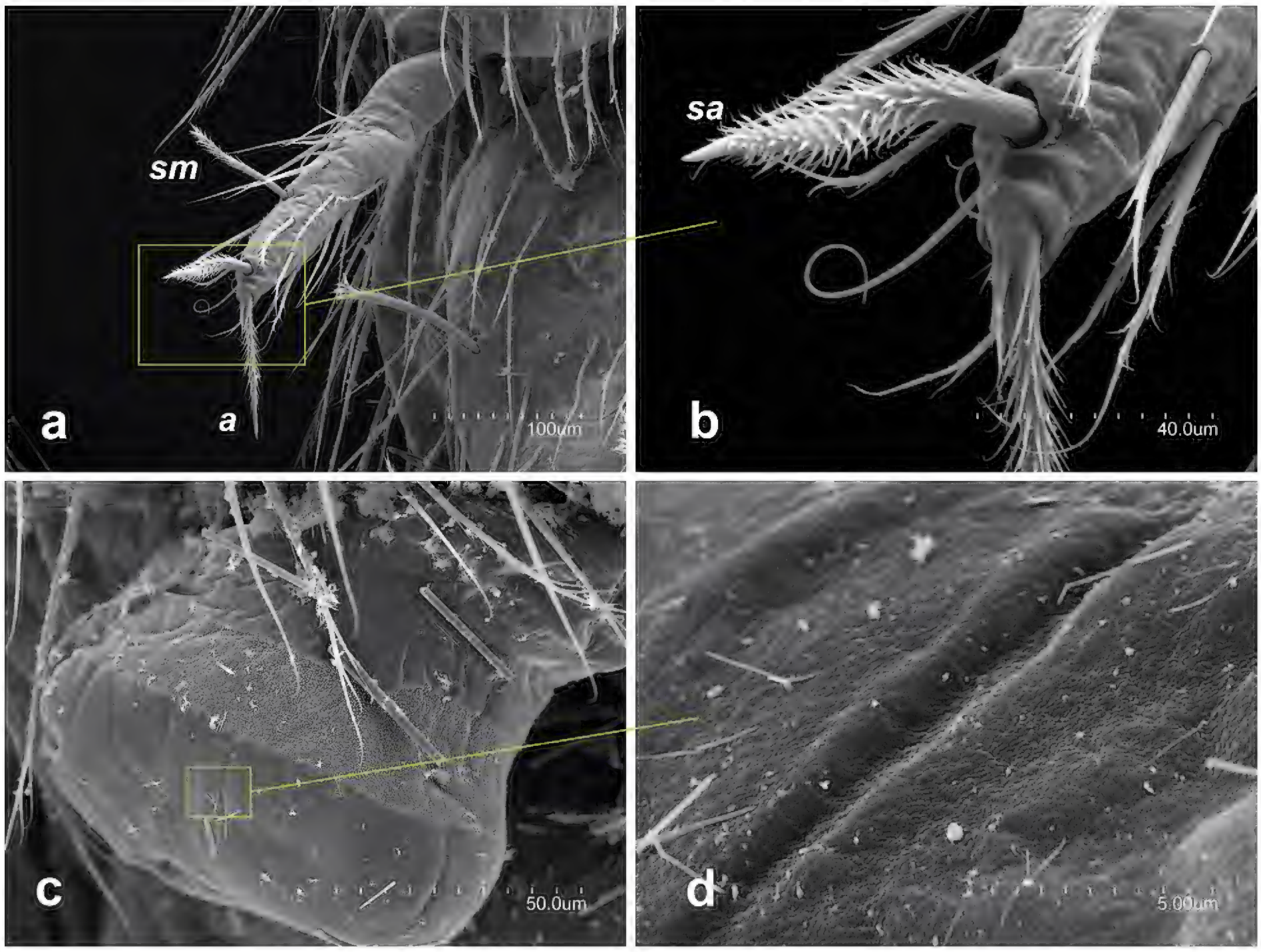

Figure 17. *Plusiocampa* (*Stygiocampa*) *bureschi* Silvestri, 1931, specimens AS coll.; **a.** Stylus fifth urosternite; **b.** Detail of apical stylus setae; **c.** Exertile vesicle; **d.** Detail of exertile vesicle. (*sm*) sterno-medial seta; (*sa*) subapical seta; (*a*) apical seta on stylus.

was recorded here from caves near the village of Chelopeк (about 3 km in a straight line from Pavolche) and Cherepish railway station (approximately 6 km in a straight line).

Plusiocampa (*Plusiocampa*) spp. indet.

Fig. 21

New material examined. Bulgaria: Western Rhodopes Mts. • 1 ex., Asenovgrad District, village Dobrostan, cave Lednitsata, 05 Nov. 2008, leg. S. Deleva, I. Naydenov • 2 ex., Asenovgrad District, village Dobrostan, cave Ivanova voda, 1320 m alt., 04 Feb. 2006, leg. B. Petrov, N. Simov • 14 ex., Velingrad District, cave Lepenitza, clay, 25 Nov. 1993, leg. B. Petrov, P. Stoev • 3 ex., same locality, 21 May 2011, leg. B. Petrov, N. Toshkova • 1 ex., Smolyan District, village Maglishta, cave Dupkata, 813 m alt., rotten log, 16 Jul. 2006, leg. B. Petrov • 1 ex., Gotse Deltshev District, village Ribnovo, cave Skoka, 1100 m alt., 18 Nov. 2006, leg. B. Petrov • 2 ex., Slavyanka Mts., cave Snyagova dupka below Gotsev vrah, 2160 m alt., 26 Jul. 2004, leg. B. Petrov • 2 ex., Vitosha Mts., Sofia District, village Bosnek, cave Zhivata voda, 1000 m alt., 27 Nov. 2002, leg. B. Petrov, P. Beron, V. Beshkov; Predbalkan • 1 ex., Lovech District, village Mikre, cave Mandrata, 365 m alt., underground stream, 11 Mar. 2007, leg. B. Petrov, I. Borisov; 1 female, Lovech District, village Bezhanovo, cave Alchashkata peshtera, 17 Jul. 1985, leg. P. Beron, B. Garev; Danubian Plane • 2 females, Pleven District, village Bohot, cave Kirov vartop, 06 Apr. 1984, leg. P. Beron; Eastern Stara planina Mts. • 5 ex., Sliven District, near Sliven City, disused mine gallery in Karandila Nature Park, 04 Dec. 1991, leg. P. Stoev • 5 males, 1 juv., Kotel District, near town Kotel, cave Prikazna, 31 Oct. 2002, leg. P. Beron.

Remarks. Unfortunately, the examined material was in very poor condition and did not allow identification to the species level. Particularly noteworthy are the specimens from the Snyagova Dupka Cave in the Slavyanka Mountains, as they may represent another, yet undescribed, new species.

Conclusion

The eastern part of the Balkan Peninsula – defined here as the area east of the Vardar and Morava rivers, south of the Danube, including European Turkey and Romanian Dobruja (excluding the Greek islands) – covers approximately 220,000 to 230,000 square kilometers. This

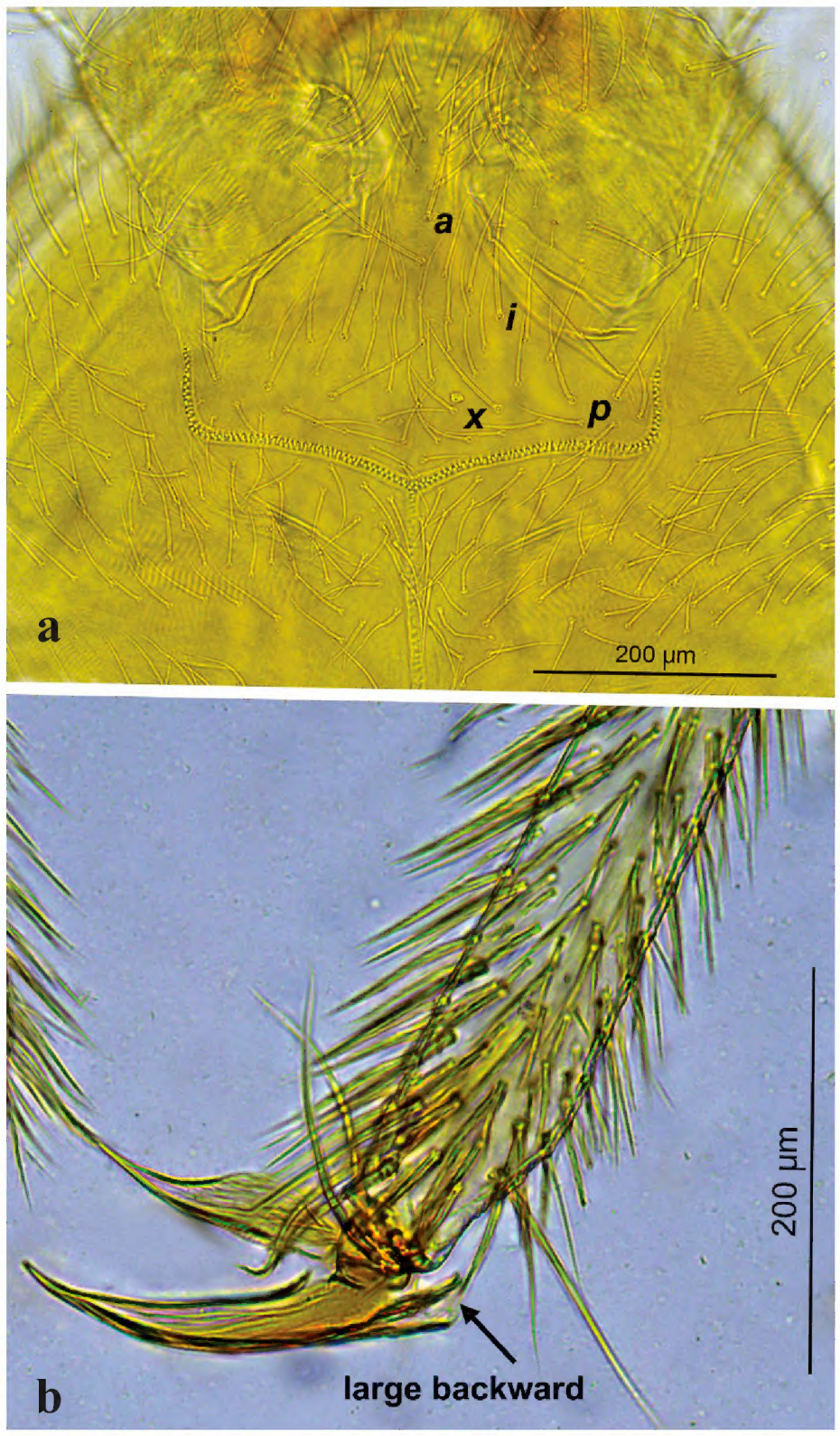

Figure 18. *Plusiocampa* (*Stygiocampa*) *petrovi* Sendra & Stoev, sp. nov., holotype – collection code Id. 10839 NMNHS: **a.** Dorsal side of the head with detail of frontal process; **b.** End of tarsus and pretarsus. Macrosetae (*a*) anterior, (*i*) intermediate, (**p**) posterior, (*x*) x setae on frontal head.

area is comparable in size to the two known hotspots of cave-dipluran biodiversity: the Dinarides and the eastern Iberian Peninsula (Sendra et al. 2020b; Sendra et al. 2021b; Sendra and Reboleira 2021a).

With the two new species described here – *P.* (*P.*) *balcanica* sp. nov. and *P.* (*P.*) *petrovi* sp. nov. – the known diversity of subterranean Campodeidae in the eastern part of the Balkan Peninsula increases from 12 to 14 species. These are distributed among the genera and subgenera as follows: one species within the genus *Campodea* (*C.* (*D.*) *neuherzi*) and the remaining 13 species attributed to the genus *Plusiocampa*. Of these, nine belong to the subgenus *Plusiocampa* s. str. (*P.* (*P.*) *arbanisiensis*, *P.* (*P.*) *beroni*, *P.* (*P.*) *bulgarica*, *P.* (*P.*) *aff. elongata*, *P.* (*P.*) *gueorguievi*, *P.* (*P.*) *isterina*, *P.* (*P.*) *lindbergi*, *P.* (*P.*) *vodniensis*, and *P.* (*P.*) *balcanica* sp. nov.), three to the subgenus *Stygiocampa* (*P.* (*S.*) *bureschi*, *P.* (*S.*) *christiani*, and *P.* (*S.*) *petrovi* sp. nov.), and one to *Didymocampa* (*P.* (*D.*) *euxina*) (Bareth and Condé 2001; Sendra et al. 2020b, 2021b; Silvestri 1931) (Fig. 21).

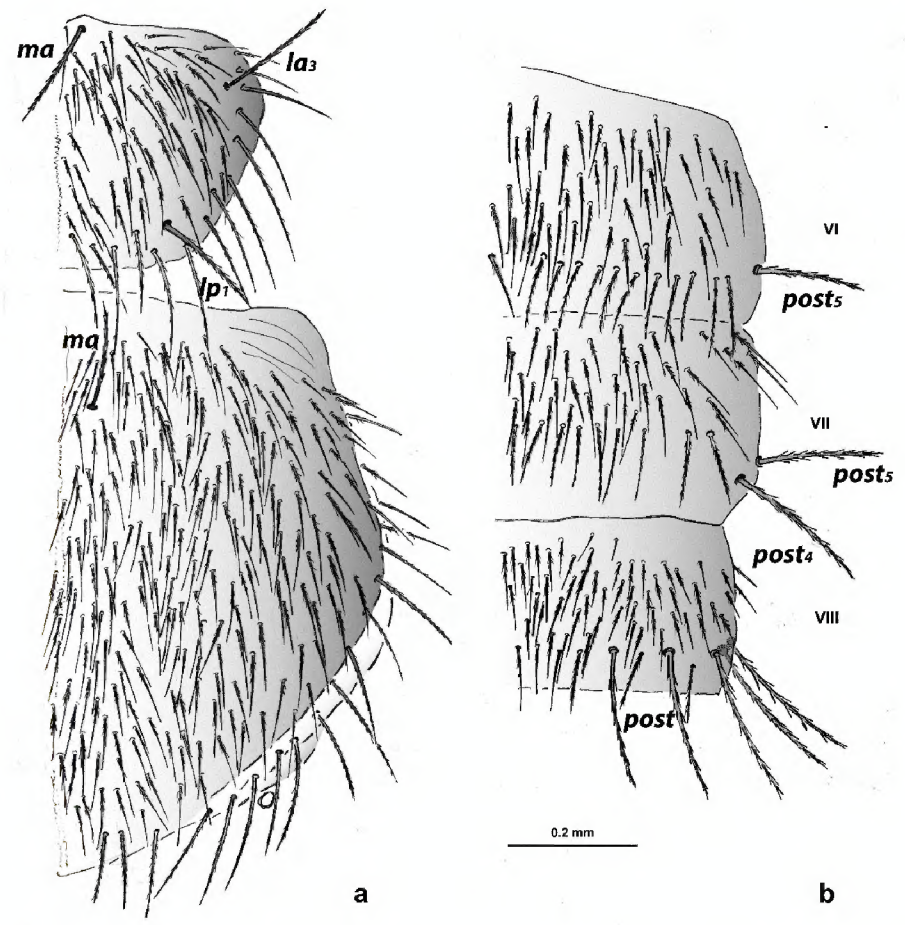

Figure 19. *Plusiocampa* (*Stygiocampa*) *petrovi* Sendra & Stoev, sp. nov., holotype, code Id. 10839 NMNHS; **a.** Pronotum and mesonotum; **b.** Urotergites VI–VIII. Thoracic macrosetae (*ma*) medial anterior; (*la3*) lateral anterior 3: (*lp1*) lateral posterior 1. Urotergal macrosetae (*post*) posterior macrosetae; (*post4*) posterior macrosetae 4; (*post5*) posterior macrosetae 5.

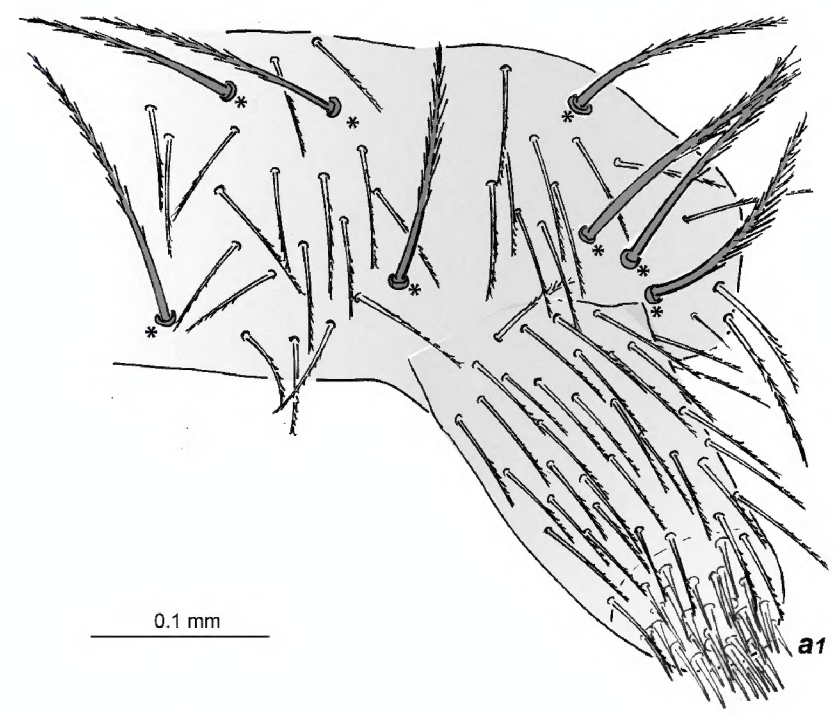

Figure 20. *Plusiocampa* (*Stygiocampa*) *petrovi* Sendra & Stoev, sp. nov., holotype, code: Id. 10839 NMNHS; first urosternite I of the female. * Asterisk position of macrosetae. Urosternites I (*a1*) glandular setae a1.

The subterranean diversity of diplurans in the Dinarides includes 15 species: one belonging to the subfamily Campodeinae and 14 to the Plusiocampinae (*Plusiocampa*). These are distributed among the subgenera as follows: seven species of *Stygiocampa*, five of *Plusiocampa* s. str., and one each of *Didymocampa* and *Venetocampa* (Sendra et al. 2021b). In the caves of the eastern Iberian Peninsula, there are 14 cave-adapted species: six from Campodeinae and eight from Plusiocampinae. The latter include five species of *Plusiocampa* s. str., two

Figure 21. Distribution map of *Plusiocampa* spp. in the eastern part of the Balkan Peninsula: *Plusiocampa* (*Plusiocampa*) *arbanisiensis* Bareth & Condé, 2001: cerise dot; *Plusiocampa* (*Plusiocampa*) *beroni* Bareth & Condé, 2001: red dot; *Plusiocampa* (*Plusiocampa*) *bulgarica* Silvestri, 1931: dark blue dot; *Plusiocampa* (*Plusiocampa*) *isterina* Condé, 1993: yellow dot; *Plusiocampa* (*Plusiocampa*) *balcanica* sp. nov.: dark green dot; *Plusiocampa* (*Plusiocampa*) *lindbergi* Condé, 1956: brown dot; *Plusiocampa* (*Plusiocampa*) *gueorguievi* Bareth & Condé, 2001: light purple dot; *Plusiocampa* (*Plusiocampa*) *vodniensis* Bareth & Condé, 2001: dark purple dot; *Plusiocampa* (*Stygiocampa*) *bureschi* Silvestri, 1931: grey dot; *Plusiocampa* (*Stygiocampa*) *petrovi* Sendra & Stoev, sp. nov.: orange dot; *Plusiocampa* (*Stygiocampa*) *christiani* Condé & Bareth, 1966: light green dot; *Plusiocampa* (*Dydimocampa*) *euxina* Condé, 1996: light blue dot. Solid black line – study area boundary.

of *Paratachycampa*, and one of *Cestocampa* (Jiménez-Valverde, in press). With these biodiversity data, we can conclude that the cave-adapted campodeids in the eastern part of the Balkan Peninsula are relatively well known compared with those of other European karstic regions.

Nevertheless, despite the many biospeleological studies conducted, the cave fauna of the eastern part of the Balkan Peninsula remains relatively poorly studied. For example, Beron (2015) summarizes the available data on the cave fauna of Bulgaria, providing information on 813 caves and 866 animal species, of which 130 are cave-adapted terrestrial species (troglobites) and 72 are cave-adapted aquatic species (stygobites). However, this represents only about 14% of the more than 6,000 caves in the country.

Similarly, Paragamian et al. (2025) summarized the data on the cave fauna of Greece. As of 2016, biospeleological studies had been conducted in 780 caves, revealing a total of 970 species. In the region of Eastern Macedonia and Thrace, 47 caves have been identified, from which 121 species are known, including 15 cave-adapted terrestrial species.

The cave fauna of Romanian Dobrogea is exceptionally rich in cave-adapted species, mostly due to the existence of the unique chemoautotrophy-based ecosystem in Movile Cave, from which 51 invertebrate species (37 endemic) are known to date (Brad et al. 2021). To the best of our knowledge, data on the caves and cave fauna of eastern Serbia, North Macedonia, and European Turkey remain scarce and have not yet been thoroughly analyzed.

That said, the subterranean fauna of Diplura in the eastern part of the Balkan Peninsula remains far from satisfactorily known, and there is little doubt that the overall picture will change as poorly explored regions are further investigated. Moreover, the application of combined molecular, morphological, and phylogenetic taxonomic analyses in

future studies will help clarify the true identity of several sibling taxa. It is likely that some species will prove to be synonyms, while others may be split into distinct species.

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